

The AMSAT[®] Journal

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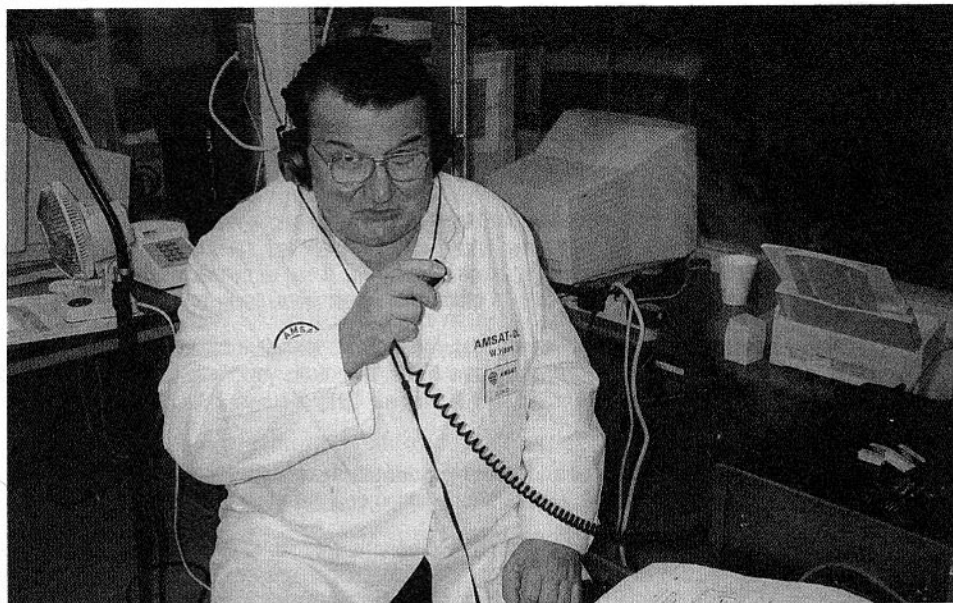
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Volume 20, No. 3

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Werner Haas, DJ5KQ, AMSAT-DL Vice President and overall coordinator for Phase 3D's communications suite, makes the very first contact through the satellite via its configuration U/V transponder in early March 1997 at the Phase 3D Integration Laboratory in Orlando, Florida. AMSAT-DL's Digital Integration Manager for Phase 3D Peter Guelzow, DB2OS, was on the other end of the historic contact using a radio just outside the clean room. During the tests, the spacecraft's LEILA (strong signal attenuator) was also tested. (AMSAT-NA photo by Keith Baker, KB1SF)

Phase 3D Comes Alive!

During the last week of February and the first week of March, major integration milestones for assembly and check out of the AMSAT International Phase 3D satellite were accomplished by members of a combined international team working at the Phase 3D Integration Laboratory in Orlando, Florida.

In a joint statement issued on March 7, 1997, AMSAT-DL Vice President Werner Haas, DJ5KQ, and AMSAT-NA Executive Vice President Keith Baker, KB1SF, gave a brief rundown of the team's significant progress over the past two weeks.

"Phase 3D is alive and doing very well!" said Werner. "We have now accomplished all the objectives we had hoped to achieve on this, our first major joint integration visit in Florida."

[continued on page 4]

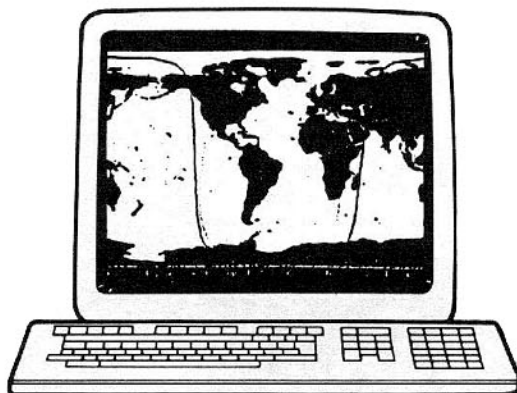
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Apogee View

No Time Wasted

by Bill Tynan, W3XO

The recent announcement by ESA that the launch of Ariane 502 which is to carry Phase 3D, has now been re-scheduled to mid-September (see page 5) upset many of our members. The subsequent AMSAT statement that this delay would probably cost the project an additional \$100,000 to \$200,000 caused a few raised eyebrows and questions were asked. A number of AMSAT members have offered various suggestions as to what actions AMSAT should take pursuant to this latest change in the launch date.

I will try to explain the additional cost and provide more insight regarding our launch arrangement with ESA.

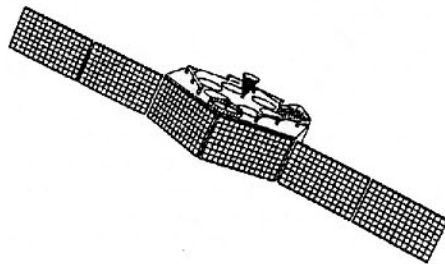
First, we must maintain the availability of the existing crew, that must accompany the satellite to Kourou to support the launch campaign. So, even if there were no more useful work to be accomplished on the spacecraft, costs would continue to mount. Second, there is additional worthwhile work that can be done on Phase 3D as long as there is time to do it. Rest assured, we will be ready for any launch date that ESA decides on. But, as long as we have been given more time, we will use it productively to further test and improve the Phase 3D spacecraft, just as I am confident ESA is doing in preparing the big Ariane 5 vehicle for launch. This process with Phase 3D is ongoing now as I write this Apogee View. In other words, the additional time we have been given will not be wasted. It will, instead, be put to best advantage. And, since time is money, more money is sure to be needed.

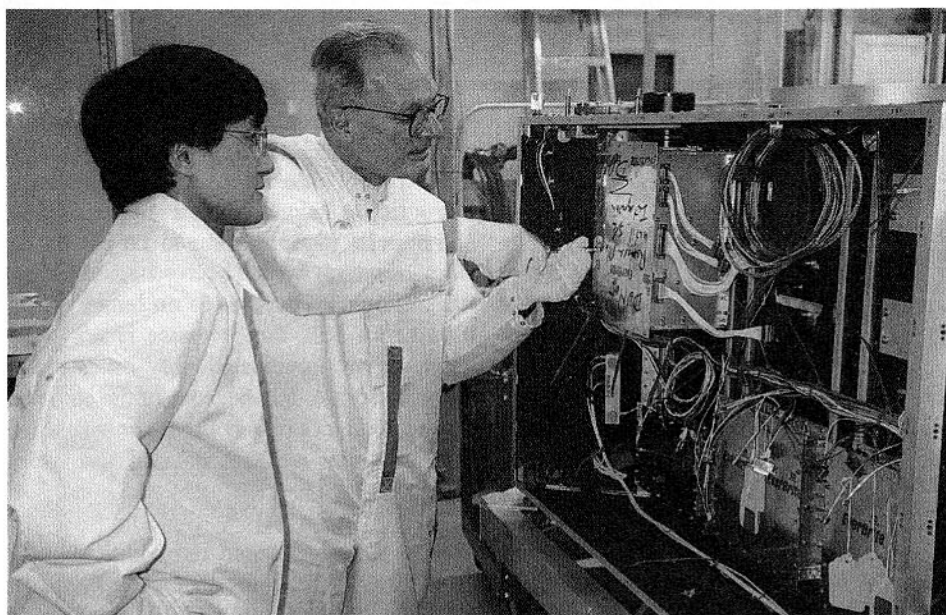
As to our launch arrangements with ESA, let me again emphasize that Amateur Radio is getting a very good deal. Even though, in our terms, we are paying a substantial sum for the launch, it is far less than a commercial customer might have to pay, even for a secondary launch position. Our launch arrangement with ESA has always been for a ride on an Ariane 5 test flight. Yes, at one point a year or so ago, there was a possibility that a commercial customer might be put on the second Ariane 5 test flight (A-502), the one we have been manifested on for several

years. That commercial payload, along with others on the flight, would have precluded the inclusion of Phase 3D. As a result, ESA made a promise to launch us on a Ariane 4, if the commercial payload were to be put on the flight on which we had been scheduled. Since the commercial payload is no longer scheduled for A-502, that promise is no longer valid. It was predicated only on us being bumped from A-502 because of the commercial payload, not on any other considerations including the eventual date of the A-502 launch.

So, we wait and spend the additional time productively. I am sure that, once Phase 3D is up and in daily use, we will look back on this delay as a benefit. In the meantime, Phase 3D continues to need all the financial help it can get. We must all act accordingly.

As announced on page 22 of the March/April Journal, it's time again for nominations for the Board of Directors. The incumbents, whose terms are expiring this year are; Dick Daniels W4PUJ, Junior deCastro PY2BJO, Bob Myers W1XT, and Bill Tynan W3XO. As Russ Tillman, KCSJVB said in his guest Apogee View editorial, in that same issue, the Board elections are very important to the Radio Amateur Satellite Corporation, or AMSAT as we prefer to call it. Think about any organization member, or members, who you think will be qualified to represent you on the AMSAT Board, and draft a nominating petition. Any five members, or an Affiliated Society, can submit nominations. All nominations must be received by Martha at the AMSAT office by June 15th. Voting takes place over the summer and the results are announced September 15th. The new Board meets following the Annual Meeting in Toronto next October. It may be called upon to meet one or more times during the succeeding year as well as be available for telephone and e-mail discussions and votes. ■





After a journey halfway around the world from Japan, Yoshiyuki (Yoshi) Takeyasu, JA6XKQ (l), from JAMSAT recently watched his team's dream become a reality when Dick Jansson, WD4FAB (r) successfully installed Phase 3D's flight SCOPE camera into the satellite. SCOPE was later powered up and *first light* received while the camera was mounted on the spacecraft at the Phase 3D Integration Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

[Phase 3D Comes Alive continued from page 1]

During this period, the combined team installed, powered up and then extensively tested the satellite's main power and computer (IHU) systems as well as transmitters for X-Band, V-Band and U-Band. All per-

formed without problems. In addition, all of the spacecraft's many communications receivers have now been built into the satellite and they, too, were thoroughly tested and are now working well.

Likewise, the SCOPE camera experiment built by JAMSAT, the Japanese AMSAT

group, was successfully installed and powered up while in the spacecraft. *First light* was also received via SCOPE during this test and the image quality of the initial pictures were absolutely superb.

Besides installing the various transmitters and receivers, Phase 3D's Intermediate Frequency (IF) switching matrix, a device that will allow most any receiver to be cross linked to any transmitter, as well as the LEILA experiment (strong signal attenuator) were also successfully brought on line in the spacecraft.

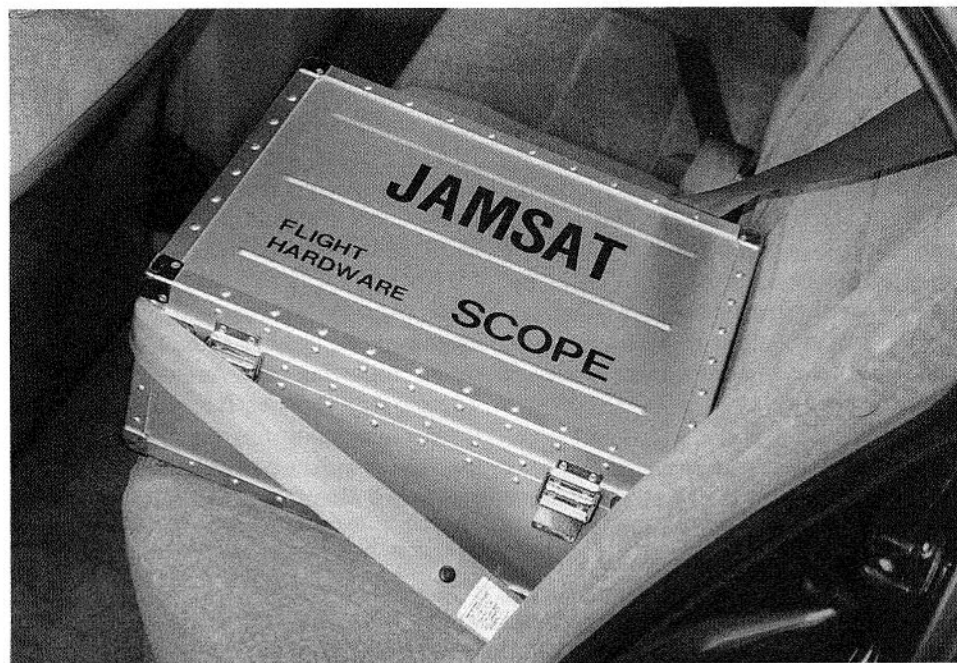
Another major integration milestone came late Tuesday afternoon, March 4, 1997, when team members Werner Haas, DJ5KQ; Peter Guelzow, DB2OS; Keith Baker, KB1SF; Stan Wood, WA4NFY; and Lou McFadin, W5DID, completed the first QSOs via Phase 3D's configuration U/V transponder. For this test, Phase 3D's U-Band receiver was cross-linked to the V-Band transmitter through the IF Matrix.

What's more, the distinctive *warble* warning tone and notch capabilities of Phase 3D's LEILA were clearly demonstrated when Stan Wood deliberately overpowered his SSB *uplink* signal, thus triggering LEILA to first superimpose its warning tone on his *downlink* signal. When Stan persisted in overpowering his uplink, team members then watched (in amazement!) as the LEILA cut his downlink signal via Phase 3D's V-Band amplifier from some 140 watts to about 2 watts! Needless to say, the members of the German communications team were most pleased to finally show their American counterparts the fine quality and function of Phase 3D's extremely capable communications suite.

On behalf of the Phase 3D Project Leader, Dr. Karl Meinzer, DJ4ZC, Werner and Peter expressed thanks for the fine hospitality shown by their American hosts. While much work remains to be accomplished, Phase 3D's final integration and checkout is progressing on schedule for its anticipated launch in September.

Phase 3D Charge Regulators Arrive

In mid-March 1997, Phase 3D team members Josef Szabo and Andras Szimler, both from the Amateur Radio Club Station HA5BME, accompanied Phase 3D's flight Battery Charge Regulators (BCRs) from Hungary to Orlando, Florida and successfully performed



After its successful journey from Japan, the metal shipping case containing JAMSAT's flight SCOPE camera experiment for the AMSAT Phase 3D satellite was firmly buckled into the back seat of its transportation for the short trip from the Orlando International Airport terminal to the Phase 3D Integration Laboratory. Needless to say, the Phase 3D integration team took no chances on it being damaged enroute, considering that just the *monetary* value of the flight camera was worth about twice the value of the automobile it was riding in! (AMSAT-NA photo by Keith Baker, KB1SF)

the all-important task of checkout and final integration of these units into the Phase 3D satellite.

These BCRs (there are three of them in the Phase 3D Spacecraft) are a critical part of

Phase 3D's power grid as they regulate both the onboard power coming from the solar panels as well as the ever-important charging functions of the main and auxiliary batteries in the satellite. BCR funding and construction was a joint effort between AMSAT-DL

and a Hungarian team under the leadership of Professor Dr. Andras (Bandi) Gschwindt HA5WH, at the Technical University of Budapest. (via AMSAT News Service) ■



Konrad Müller, DG7FDQ, AMSAT-DL Structural Specialist making final adjustments on the Phase 3D momentum wheels. (AMSAT-DL Journal photo)

Phase 3D Launch Delayed Until September 1997

In a formal announcement from Paris on March 24, 1997 the European Space Agency (ESA) said that the second test flight of their new Ariane 5 booster has now been re-scheduled from July to mid-September, 1997. It is this flight, Ariane 502, on which Phase 3D is currently manifested. According to their latest announcement, this action was being taken by ESA and CNES (the French Space Agency which manages the Ariane 5 program for ESA) in order to "improve (the booster's) robustness, increase the operational margins and allow for degraded operating modes."

In a joint statement a day after the ESA announcement, Phase 3D Project Leader and AMSAT-DL President, Dr. Karl Meinzer DJ4ZC, along with AMSAT-NA President Bill Tynan, W3XO, expressed continuing confidence that ESA and CNES will succeed in completing all the tasks necessary for a successful flight test of Ariane 502.

"Naturally, we are disappointed that our launch will not be as soon as we had hoped," said Meinzer. "However, I am pleased that ESA and CNES are taking care to improve the operational margins for the Ariane 5 booster. This action helps give us renewed confidence in the overall probability for a successful launch of our satellite," he said.

Both Meinzer and Tynan emphasized, however, that this launch delay, like the earlier ones, means that the total cost of the Phase 3D Project will increase significantly. Even before the latest ESA announcement, AMSAT-DL and AMSAT-NA were projecting a combined budget shortfall of about US \$200,000 needed to complete their respective tasks on the project.

"This shortfall can only increase now as a result of this latest schedule change," said Tynan. Both AMSAT leaders urged everyone to continue doing as much as they possibly can to ensure the needed funds will be in place for the completion and launch of Phase 3D. (via joint AMSAT-NA and AMSAT-DL press release) ■

Phased Verticals for RS-12

John Alan Hackett, LA2QAA
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Due to the apparently increasing interest in RS-12 here in Europe of late, I thought I'd describe a 15 meter antenna system I constructed several years ago.

The system is comprised of four verticals phased for 0, 90, and 180 degrees...(for the newcomer: *electrical* as opposed to *direction* degrees). Without delving too deeply into antenna mechanics, the newcomer may find the phasing harness somewhat confusing. However it's rather like a car! You don't need to be a motor mechanic to drive one nor

do you need to have a graduate course in antenna theory and design to use this aerial. You just follow the instructions....(and hope for the best!.....LA2QAA).

The system I describe here is one I have used successfully for many years and was, to the best of my knowledge, first described by W1HKK, describing a phased vertical array for 80m!. It first appeared in 1968!. I *lifted* the idea, did a bit of experimenting and transcribed the antennas and phasing harness for the 15m band. I used the antenna with great

success for many years on HF and achieved DXCC with home brew 2 watt QRP CW gear together with the phased array. My 15m version of the phased array was first published in *Amateur Radio* in 1989 and now is appearing in "THE" Journal. You could say it's finally *come home*.

One of the main advantages of a switchable phased array as opposed to the mechanical rotator system is the time it takes to *turn the beam*....milliseconds as opposed to 45-60 seconds. Picture this: exotic DX on frequency, beam in the opposite direction (Murphy's Law), crank the beam around...etc....only to find that exotic DX *buried* by everyone from Sydney, Australia to Kowloon! However, with the phased array it's a different story. Hear the DX, click the switch and *ZAP* you've *bagged* him before the rest have time to pull their pencils out of their mouth. The other main advantage of a phased array is the front to back and front to side ratio. This is increasingly more important as the bands become overcrowded, especially so if the have a kilowatt station right behind you.

So to the construction side. The first thing that must be stressed is the importance of the radial system in a ground plane type phased array. *Theory* dictates that the perfect ground plane is a solid silver ground plane extending from the base of the aerial for *at least* a quarter wavelength in a temperature of 20 degrees Celsius! (Try that on Frei Island, Norway with a very *limited* economy!) Therefore we must compromise and make the *best* ground plane we possibly can since the ground plane is directly proportional to the *efficiency* percentage of the aerial. (For those of you who are as *thick* as I am, this means as many radials as possible!).

W1HKK's article stated a gain of 9dB was possible with a good ground plane. I think he was just *slightly* optimistic with that figure. However, 7.2dB is feasible/possible with a *good* ground plane. (I don't have a proper test range so my figures are merely *tried and tested*.) However, I did make the effort to do extensive tests with the means at my disposal and I can assure you the system is more

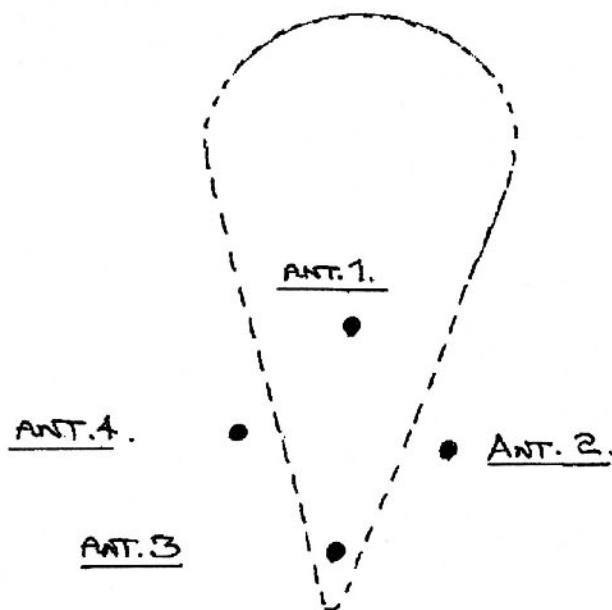


Figure 1. A birds-eye view of the array in a diamond configuration. For clarity (I hope!) the radial system is not shown. Each antenna has it's own radial system composed of as many! radials as possible. The dotted line shows the main radiation lobe when the array is in the 0 (zero) degrees position.

By means of the phasing harness described later, the array can be switched in any one of four directions and phased to give maximum gain in that direction while at the same time providing both front to back/front to side in the unwanted directions....i.e....in the diagram...antenna 3 at 0 degrees, antennas 2 and 4 at minus 90 degrees and antenna 1 at minus 180 degrees. Each antenna is spaced 1 quarter free space wavelength from it's neighbor which, at the center of the passband for RS-12 is 354cm....(yea yea!...I know you lot use feet n' inches....so go buy a calculator!). Each vertical element is 338cm long. The expert may modify that with the length to diameter ratio formula. However, for the newcomer forget it! Cut the element on the long side, a few cm will suffice (sorry...inches!) and then trim each antenna for resonance at 21.230 MHz before connecting it to the phasing harness/relay box. Remember to use as many radials as possible. Each radial should be 336cm long.

effective than six Coca Cola cans tied together with wet string! (No! I don't get a commission from The Coca Cola Company). One thing the *newcomer* may find daunting is the reference to *Wilkinson power dividers*. Don't panic chaps! This is just a fancy name for a couple of *tactically* placed resistors to dissipate standing waves throughout the phasing harness thereby contributing to an even distribution of RF. Or, think of them as little cops on traffic duty....Hey you!...SWR...This is a one way street!!!

So what do we need and what will it cost?...not a lot! and not a lot!....All you need is some aluminum tubing (I've often used house wiring stapled to wooden poles!), a few *stand-off* insulators (PVC pipe over the tubing and fastened with automobile clamps), six relays, and beg, borrow, or *steal* a 12 volt power supply and the necessary phasing lines comprising pieces of quarter-wave (*electrical*) lengths of 50 and 70 ohm lines. You'll also need three 100 ohm resistors...non-inductive! types...i.e...*not* wirewound. They don't need to be high wattage unless you plan to throw a few thousand kilowatts up the sharp end. (They're there to dissipate returning energy on the line so use whatever is appropriate to the power you intend to use. Anyone *caught* throwing excessive amounts of RF at any satellite ought to have his transmitter *steamrollered* anyway!)

I hope the four figures with this article are completely self explanatory (you are! a Radio Amateur are you not?). If not, go out and buy a rubber duckie, ducky!

A Post Script Observation's From Norway

Editor's Note: As with LA2QAA's last article that appeared in the January/February issue of The AMSAT Journal, here's another edition of Observation's from Norway. John also publicly thanks all who answered his request for back issues of The AMSAT Journal.

FO-20

FO-20 QSO's seem to be rather *thin on the ground* (!) lately. Whether this is due to increased activity on FO-29, family commitments, pressure of work or just plain laziness/lack of interest I'm not sure but it's getting a might lonely around 435.850 MHz of late so anyone with an excess of goodwill

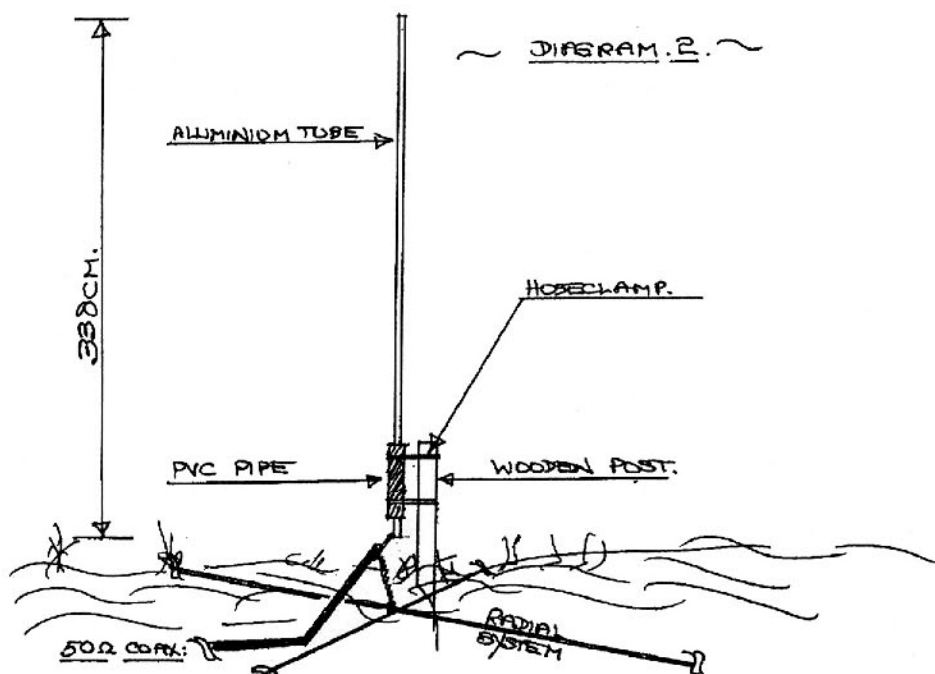


Figure 2. Each length of 338cm tubing can be clamped to a wooden stake by hose clamps over a short piece of PVC tubing. You wouldn't do this at microwave but at 15m it's adequate unless you plan to use 6 kilowatt transmitters in parallel in which case you shouldn't be on satellites anyway! The inner conductor of the coax is fastened to the base of the tubing by means of the builders choice method and is 30cm over the ground at my location due to the snow in winter. If you plan to mount this antenna in the middle of Times Square, five cm over the sidewalk should suffice. The coax braid/shield is connected to the groundplane which in turn is also connected to a metal stake driven firmly into the ground. You could use a piece of massive metal ensuring a good Earth ground for the system but do remember the dissimilar metals theory. That is, don't bolt the copper wire to an aluminum plate with a steel bolt. It will quickly corrode and the electrical connection will be broken. (Then you'll have to dig it all up again, won't you? Think first, do after!) Each feeder then goes to the appropriate connection on the phasing harness and relay box. The box should be at the center of the array so that the coaxial feedlines can be of equal lengths.

It's a good idea to place a plastic bowl over the top of the phasing harness/relay box to keep out the elements (in Norway, rain and snow...eagles in the U.S.?). Make sure you seal all connectors with self amalgamating tape or in the case of those of you who like me are financially embarrassed use well chewed Wrigley's gum! Strictly speaking, one should use a length of coax in each feedline as an impedance transformer to ensure correct matching but I've found the time/cost not worth the effort. The SWR in the system as described is well under the acceptable 1.5:1....right!, calculators out...to see if I'm lying through my teeth....actually, I'm not!

is invited to join me on an otherwise quiet transponder on the morning passes...if only to stop my slide into dementia...by talking to myself!.

I had trouble when trying to flush the cistern afterwards. Perhaps someone could suggest to the people responsible, the idea of a schedule is to provide pertinent information preceeding an event as opposed to succeeding it.

FO-29

As far as I can ascertain, FO-29's current schedule seems to be: analogue mode while everyone is asleep and digital while those of us without PSK modems are awake. I did receive the correct schedule for the 24th and 25th of December 1996, however, since I received it on the January 10, 1997, I have not found a use for it yet. Actually I have, but

AO-27

I have purchased a commercial microphone stand on which I've placed a 6-element 70cm and 3-element 2m antenna. It is very easy to elevate, etc and this together with the FT-28E (2m transceiver/70cm receiver) handheld makes for an excellent portable QRP AO-27 station.

RS-10

In preparation for his first RS-10 QSO I've been teaching my dog Morse. A rather laborious process because he prefers semaphore with a pair of flags tied to his tail! This system works well until we pass a butcher shop whereupon the signals become too fast for me to read! Incidentally, his callsign is K9DOG (think about it....canine!).

Mode-S

After having seen David Bowman's GOMRF excellent article *An S-band to 70cm RX Converter* within these hallowed pages I decided to throw caution to the wind and attempt the project. Having previously disposed of my soul in part-exchange for the 70cm rig, I wondered how to raise the capital for the kit. I much prefer the old barter system. I'll give you three chickens and a goat for your cow, etc. But realizing that livestock were frowned upon as economy flight passengers with British Airways and also that GOMRF probably wouldn't appreciate a pair of matching penguins as payment, I sent him a postal order instead which was donated by the XYL and classed as my Xmas *pressie*

(for the next 17 years!). After the clauses of the contract were thrashed out with the XYL (these include washing up without protest!...remembering where the vacuum cleaner resides and scrubbing the floor! for "n" number of weeks hereafter), I set about gearing up my last remaining active brain cell. What did I know about 2.4GHz?.....about enough to fill a gnats backpack!.....naught!....(Manchester vernacular: nothing!). This is where back issues of *OSCAR News* and *The AMSAT Journal* are *invaluable* to a newcomer. After going through the previous five years of issues for both magazines, I collected a positive mine of information on Mode-S which I read, re-read and digested. After which, I'd learned, since AO-13's demise (rest its soul), the only satellites currently having Mode-S beacons were DO-17, UO-11 and PACSAT...all being LEO's which streak across the sky like an F-15E with a tailwind. Obviously a 20dB/18 degree beamwidth dish won't do for these birds as James Miller G3RUH correctly points out (your average rotor rattles more than that). Consequently, a pair of helices were wound using the formula from James's *Smallest is Best* article. A quick fiddle on the Woolworth calculator re: veloc-

ity/distance/ accuracy/gain required, etc. gave me an answer as strange as a three dollar note! So I settled on 10 turns for both port and starboard. I *know* for UO-11 you need LHCP and I *assume* RHCP for PACSAT. Both helices are mounted on the aforementioned microphone stand which now resembles a kind of futuristic death ray!....Flash Gordon's got nowt on me mate!....the *locals* are a little skeptical to the new *plant* in the garden and it's rather comical to see the birds...feathered variety!....alight on the front of the 45 degree inclined helix only to find themselves helter skeltering....tailfeathers-over-beaks at a rapid rate of knots toward the N-connector and reflector plate...which, luckily for their feathered bums has no sharp edges ensuring they don't impale themselves but only hit the ground with a slight dent in their dignity.

I digress.....I now eagerly await the arrival of SMD components for the GOMRF converter...(this'll be a 'larf)....mainly due to the fact of not only am I as thick as the proverbial *two short ones*, bald and bordering on senility. I'm also near to being blind as a bat! I considered asking the XYL and daughter for construction help but since we have a collective IQ of 2.9! I thought better of it. A report of LA2QAA's first attempt at microwave construction will contaminate (!) the next issue of the *OSCAR News*. (For those unfortunate enough to live on the wrong side of the Atlantic I'd better explain the *two short ones*.....As thick as *two short planks* is the *polite* form for a dimwit!)

On a more serious note.....for the newcomer....an antenna that has high gain (i.e. feedhorn with parabolic reflector) has a narrow beamwidth. This means that pointing accuracy for a given satellite in low earth orbit with a high Doppler rate must be very precise. By lowering the gain one widens the beamwidth and thereby makes pointing accuracy less stringent. The higher one goes in frequency the more pronounced is the effect of Doppler on the received signal. You can check this by first listening to RS-10 on 10m, note the Doppler then tune in RS-12 on 2m, thereafter tune in FO-20 on 70cm and note the rate of change of the frequency due to Doppler effect. You'll now have a fair idea what it's like on 2401.222 MHz. Extremely *sharp* beams are best suited to geostationary satellites that appear to always be in the same portion of the sky. This is due to the fact that they are in an orbit over the equator and move at the same speed as the Earth's rotation giving the impression that they don't move at all.

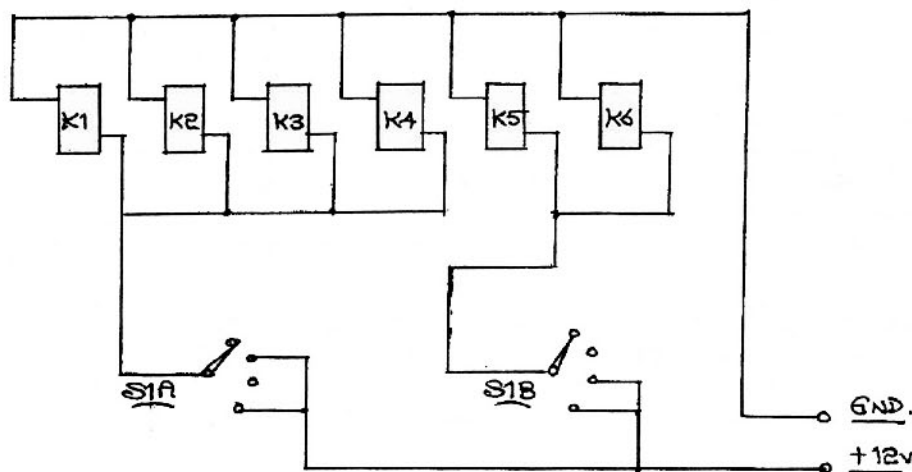


Figure 3. The relay system should be self explanatory. Switching the array in one of four directions by means of a 2 by 4 pole rotary switch at the operating table. Newcomers remember that long runs of cable carrying 12v means voltage drop so if your antenna is more than two miles from the operating position you'll need more than the nominal 12v to operate your 12 volt relays. Most relays will operate at a voltage lower than their nominal working voltage but don't push your luck! If it says 12v use 12v. That is, measure the voltage at the relay not at the power supply.

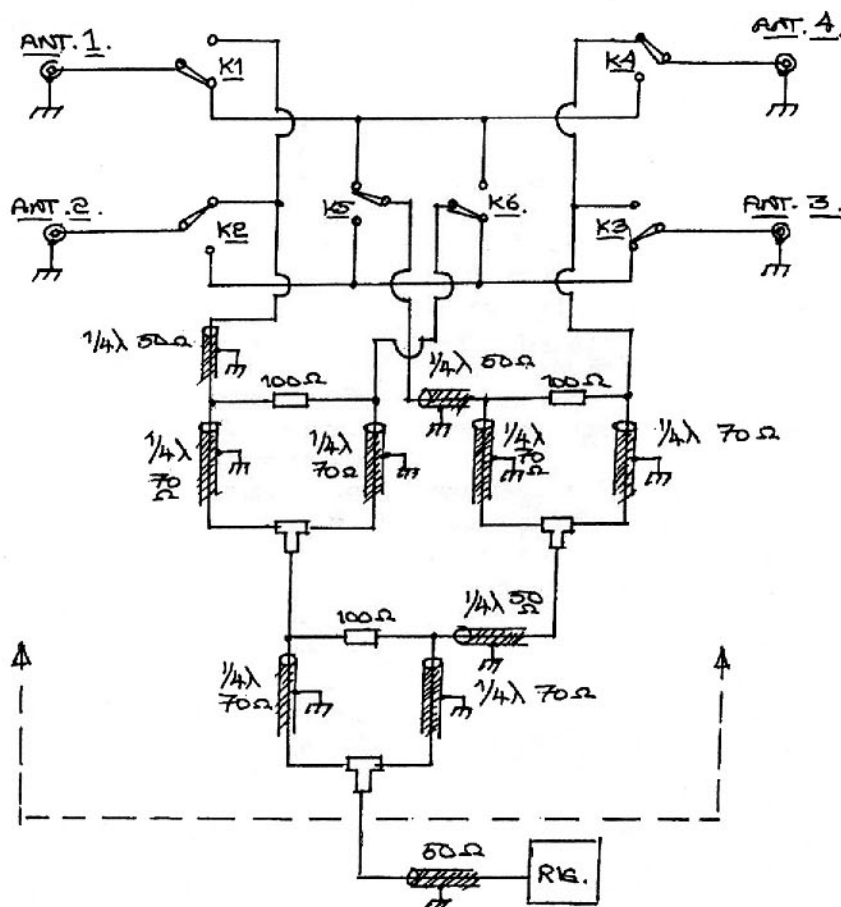
I've filled several *nutshells* with what I've learned from past issues of *OSCAR News* and *The AMSAT Journal* so I can thoroughly recommend this method to any newcomer wishing to learn more about satellites. There are several articles by Ed Krome K9EK, James "The Boss" Miller G3RUH (in respect, James) and David Bowman G0MRF among others. So if like me you're tired of the "DC" (2m) band QRM (Aarrggghhhh! cow giving birth)...or...is this frequency in use?...on top of your QSO...and you're looking for a challenge...try Mode-S...I've been unemployed for five years! So the *can't afford* it excuse isn't good enough anymore.

Phase 3D

On the subject of potential newcomers to the satellite scene. Despite the *Oscar News* Elmer column and *The AMSAT Journal's* frequent advice to newcomers to drop a line to Sligo Avenue or West Sussex, I believe a lot of newcomers will suffer from the same fate as I did when I first became interested in the *birds* (!). That is, being afraid of asking for fear of being labelled *dim* by the *experts*. It's a fact of life that any organization with more than three members has a hierarchy...and a fair amount of people...(wrongly?)...assume that *asking* is a waste of time. Therefore, if the mountain won't come to Mohammed, Mo' must go to the mountain! By this I mean to save unnecessary QRM/varying operating procedures/habits etc. may I respectfully suggest that a set of rules be included with the *Procedure Handbook for Operating Phase 3D* ...NOW!.....which can then be translated into their national languages and be distributed with their national magazine. This way *everyone* operates from the same set of rules. To do this now is far more sensible than waiting until Phase 3D is (hopefully) aloft and *then* trying to sort out the varying operating techniques. I'm not referring to a schedule. I mean things like the importance of the TX signal in relation to the beacon, which way to tune for Doppler, TX/RX etc. so we may avoid confusion. There will be those that ignore the rules. There always are but the vast majority of newcomers will be making their very first satellite QSO on Phase 3D. AMSAT should *teach* them how to do it painlessly! By explaining *the right ascension of the ascending node* will only gain the response...*yer' wot?*.....remember the panic/thrill of your first QSO? A good set of ground (!) rules will be of benefit to everyone!.

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~ ALL PHASING LINES & RELAYS CONTAINED IN ~
~ CONTROL BOX ~



~ MULTIPLE OF $\frac{1}{2}\lambda$ 50 OHM COAX FROM CONTROL BOX TO STATION.~

Figure 4. The combination of 50 and 70 ohm phasing lines/resistive power dividers ensures that the correct impedance is maintained throughout the system, while at the same time giving the correct phase in each direction selected. If you have a good ground plane the forward gain should be in the region of 7dB and the front to back a very respectable 25 dB, the front to side somewhere between 12 and 15 dB while the vertical radiation angle will be about 19 degrees which is perfect! for low horizon (DX) passes and perfectly reasonable up to about 40 degrees. After that it drops off a bit but remember the LEO's spend most of their time messing about between 10 and 30 degrees elevation. A disadvantage (some may say) of the system described is the linear only, polarization. I'm working on it but so far I haven't come up with a circular polarized phased vertical array!

That's yer' lot folks!....time fer' me' tea.

73 John.

P.S. As usual...criticisms to the...(illustrious)...editor...monies...(no three dollar notes please)... and praise! to me. ■

RS-16 and Svobodny Cosmodrome News

RS-16

As mentioned in the last issue of *The AMSAT Journal*, RS-16 was successfully launched into orbit. The following are relevant portions of a message from Leo Labutin, UA3CR, to Pat Gowen, G3IOR, giving further information about the current state of RS-16.

RS-16 is now (20MAR97) under testing. The duration of this test period may take two or more months. As you probably know, RS-16 is the first launch from the new Russian Svobodny Cosmodrome, in far eastern Russia about 200 km from the Amur river and Chinese border. The city of Svobodny is located on the bank of the very stormy river Zeya. Upon this river came Zeya, the official name of the satellite.

Because this was the first launch from Svobodny Cosmodrome, officials did not want to risk putting in orbit an expensive and large satellite. A good solution was a satellite for Radio Amateurs and some small scientific programs. And we are lucky as the same time a Ground Control Center (GCC) is checking all facility, equipment, antennas, etc. All RS-16 commands are only taking place from the GCC. While there is yet no amateur command station for RS-16, GCC also commanded AO-21/RS-14 from a location just near Moscow and not far from UA3CR's new shack.

Two members of the RS-16 group working at GCC are Alex Papkov, RA3XBU and Victor Samkov. The others are military and factory persons. Zeya includes RS-16 equipment and also an experimental navigation system Glonass/GPS of the Terminator series and a number of experimental reflectors, solar panels, and charge battery. High speed RS-16 telemetry includes many parameters for the other experiments on RS-16, so it is very important to get good downlink signal from the 70cm beacon. However, presently (20MAR97) there is a deep QSB problem due to satellite rotation.

While the GCC is not equipped with good 70 cm RX's, antennas, and tracking/Doppler control, UA3CR's satellite station is improving. Every day he discusses downlink reception with GCC in hopes of improving telemetry reception. UA3CR asks Amateurs to check the band around 70 cm beacon as it seems some spurious signals and noise are present +/-30 kHz. He suggests this may be my RX overloaded with strong QRM.

UA3CR also provided photographs of Zeya operations which are included as Figures 1 and 2.

Svobodny Cosmodrome

Meanwhile, Philip Chein, KC4YER called *amsat-bb* readers attention to the

following WWW site address: <http://www.rssi.ru/SFCSIC/svobodny.html> for additional information on the Svobodny Cosmodrome. The following information is taken from their WWW page:

The main facilities of the Cosmodrome are situated in Svobodny district of Amur region in the square limited in latitude by 51°40" to 50°00" North and in longitude by 128°00" to 128°30" East.

In the first development stage of creation of the Cosmodrome, five silo launchers remaining after a rocket division disbandment in accordance with the Strategic Arms Limitation Treaty and will be used for launching procedures (Figure 3). The second stage is to construct a multi-purpose launch complex for *Angara*, a launch vehicle for the 21st century which uses an ecologically pure propellant.

Only a few years ago the mere idea of building another cosmodrome in the former Soviet Union would have been viewed as absurd. All the space launches had been effectively handled by Baikonur and Plesetsk. However, following the breakup of the Soviet Union, the Baikonur Cosmodrome ended up in sovereign Kazakhstan, with most of the land-based space infrastructure remaining in countries outside Russia.

Since Russia can operate Baikonur facilities for twenty years under the relevant leasing agreement, this circumstance has so far caused no major alarm. In addition, the Russian Federation has one more operational cosmodrome at Plesetsk in the Arkhangelsk region. If our relationship with Kazakhstan sours, Russia's access to outer space would be limited and billions of dollars would never be earned. Plesetsk is situated up northern Russia, while low-latitude space launches are more power-effective in Baikonur. Also the Plesetsk Cosmodrome still lacks a launch complex equipped to fire heavy Proton LVs that are only launched from Baikonur. All things considered, the experts concluded that Russia needed one more state-of-the-art cosmodrome.

A scheme was engendered to build a space center in the Russian Far East. Before choosing the actual location, protracted research and surveys were conducted.

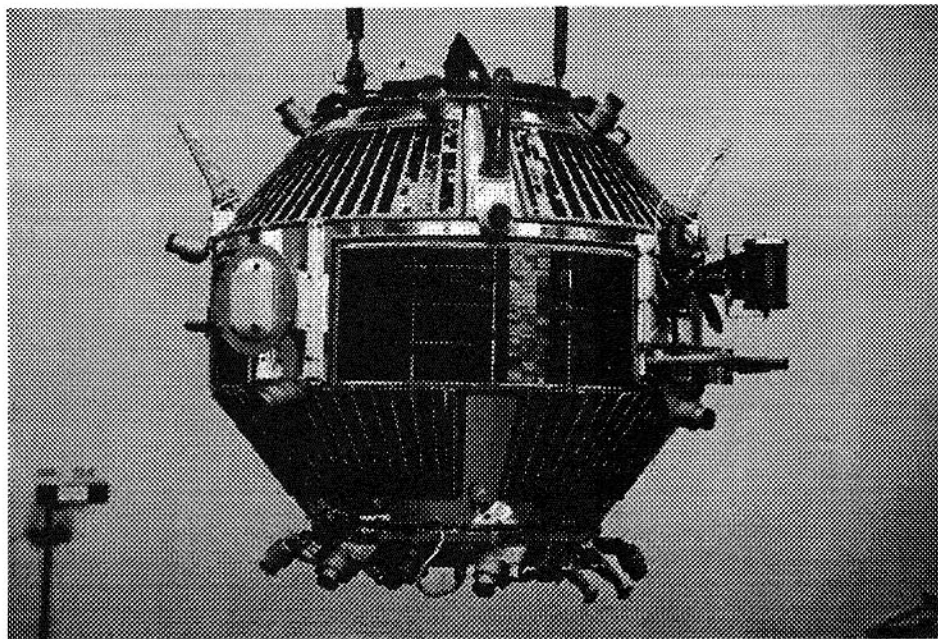


Figure 1. A prelaunch photograph of RS-16 (Zeya) provided by Leo Labutin UA3CR.

Svobodny-18 was selected from three candidates. An ad hoc interagency panel, comprising officials from the Defense Ministry, Russian Space Agency, State Committee for Defense Industries and other federal bodies approved the new cosmodrome project and gained the approval of Amur regional administration. Under the Russian Ministry of Defense's directive of November 30, 1993, all the assets of the missile division, originally deployed there and now deactivated, were to be transferred over to the newly established Space Test and Control Center, with skilled and experienced personnel appropriately selected to operate available space and missile assets. The efforts to build a new cosmodrome in the Russian Far East were approved by the President of the Russian Federation, Boris Yeltsin as he visited the Amur Region in 1993. A relevant Presidential Decree of March 1, 1996, approved the construction of the second State Test Cosmodrome of Russian Ministry of Defense (MoD). This move provides for sensible redundancy of Russia's capacities engaged to support military space activities. If all space launches were performed at Plesetsk, the area's environmental situation might be put at risk. What is more, all leading space powers are now known to maintain such back-up capacities. For example, the U.S. operates four space launch centers. There are three in China, and two in Japan.

Here are a few specifics of the new cosmodrome. The space center is situated nearly on the latitude of Baikonur, allowing for the effective use of launch vehicles targeted to place satellites in low-inclination orbits. One booster fired from Svobodny would insert in orbit with 20-25 percent more payload weight than when fired from Plesetsk.

As the world average cost per kilogram of orbited payload ranges between U.S. \$20,000-30,000, any enhancement in the launch vehicle cost-effectiveness would inevitably produce an economy of scale. The Svobodny Cosmodrome will be equipped to support launches to secure all kinds of orbits (geostationary, sun-synchronous, low-inclination) as well as provide deep-space research missions. Down-range drop zones of the Svobodny Cosmodrome will cover uninhabited remote areas in the Russian Far North and the neutral waters of the Arctic and Pacific Oceans. Dedicated trajectory and

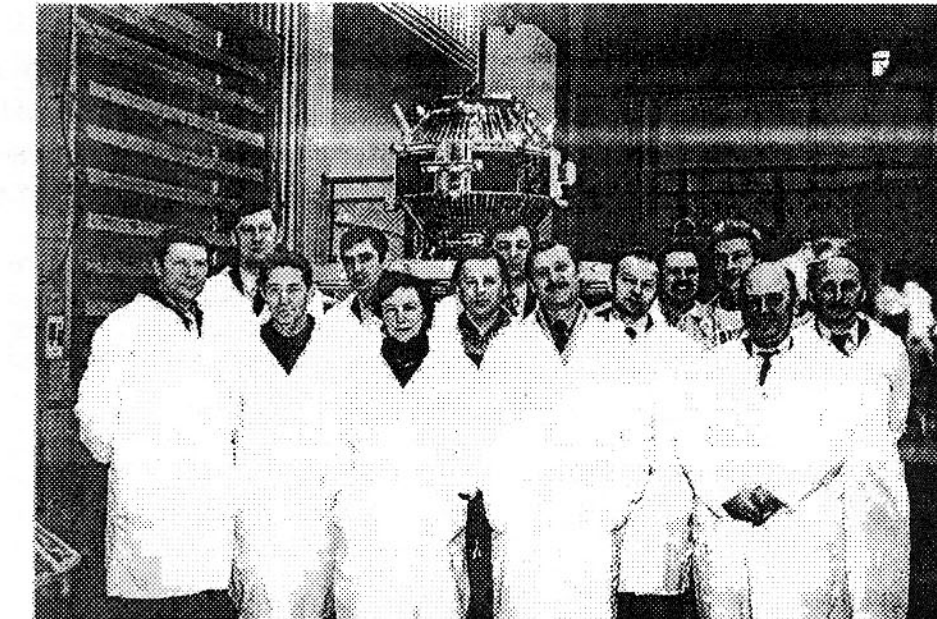


Figure 2. Launch team with RS-16 in background. (Photo via Leo Labutin, UA3CR)

telemetry-measuring sensors are installed throughout the Russian regions lying under the boost legs of launch vehicles.

The Svobodny Cosmodrome already operates a developed infrastructure, comprising five launch silos and the appropriate launch vehicle testing and integration base (over 300 sites in all). Following some improvements, the space center's facilities would be fully equipped to send aloft light Rokot and Start boosters. Loads can be delivered to the Svobodny Cosmodrome by any means of transport. The following transportation links located nearby are: the railroad junction of Ledyanaya (the Transbaikal Railroad), linked with the space center's network of rail tracks; the Moscow to Vladivostok highway; a first-class airport in Ukrainka equipped to receive all types of aircraft; and the river port on the Zeya River. Given the country's complicated economic situation, the Svobodny Cosmodrome is expected to be engaged incrementally, before it is fully commissioned. In the first stage (1996-1997), the existing assets will be activated to support light Rokot and Start LU

launches: the project requires about 100 billion in subsidies at current prices, which would make six percent of Russia's annual resources committed to support the Baikonur Cosmodrome (including lease payments). At present, work is in full swing at the Svobodny Cosmodrome to complete construction of the two launch complexes, with one scheduled to be used in the fourth quarter of 1996 to launch a Start-1 LV with an U.S.-made mapping satellite, and fire a Rokot LV in 1997.

After the turn of the century, a standardized launch complex will have to be built to handle the heavy *Angara* LV. Funding has been estimated at being close to R4.5 trillion, comparable with the spending level needed to keep Baikonur operational for three years. ■

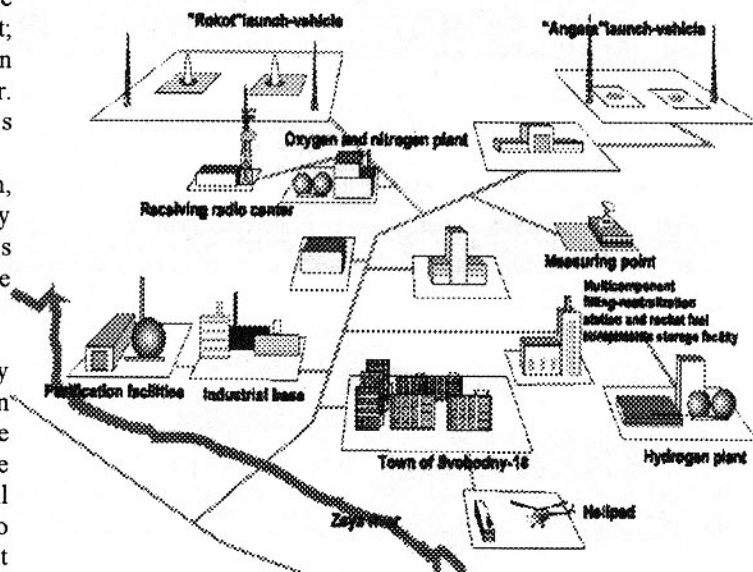


Figure 3. Schematic of Svobodny Cosmodrome.

ASUSat 1: A Low-Cost Amateur Radio Nanosatellite

Shea Ferring, Joel D. Rademacher, Clarence McAllister, Assi Friedman, Helen L. Reed,

Jordi Puig-Suari, and other members of the ASUSat 1 Team

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Arizona State University, Tempe, AZ 85287-8006, USA

In October 1993, the students at Arizona State University (ASU) were challenged by Orbital Sciences Corporation (OSC) to develop a 4.5-kg (10-lb) satellite (ASUSat 1) to be launched as a piggyback payload on a Pegasus rocket. The challenge also included the requirements for the satellite to perform meaningful science and to fit in the payload adapter cone section above the avionics (0.02 m^3). These physical limitations as well as severe cost restraints resulted in a design and development process which was fundamentally different from that of traditional space projects. The spacecraft capabilities and scientific mission evolved after cost, size and weight limits were established. This design philosophy can be applied to future interplanetary spacecraft. In addition, the ASUSat 1 program demonstrates that universities can provide an open-minded source for the innovative nanospacecraft technologies required for the next generation of low-cost planetary

missions, as well as an economical testbed to evaluate those technologies. At the same time, the program provides hands-on training for the space scientists and engineers of the future.

University satellites provide a unique opportunity to combine the educational and research missions of a university in a single program. Students have an opportunity to work in the multidisciplinary work environment which is common for many engineers today. Limited resources and rigid constraints lead to development of innovative technical solutions ranging from the design of new low-cost components to the development of manufacturing techniques that can be easily performed by students with little manufacturing experience.

In recent years, the entire space community has been faced with new constraints including lower budgets and shorter design

times. In this new environment, the kind of thinking found in university satellite programs may provide some of the solutions which are required for the success of space exploration in the future. This paper describes the ASUSat 1 project. This is only one of the many university satellite programs currently under development. It is the authors' opinion that such projects can make valuable contributions to the aerospace field, not only by training scientists and engineers, but also as a tool for the development and testing of new technologies.

Program Overview

The original challenge made to ASU students by Orbital Sciences Corporation (OSC) co-founder Scott Webster in October 1993 was to design and build a 4.5-kg satellite to perform meaningful science in space. The satellite would be placed in the payload adapter cone section above the avionics of the Pegasus rocket, with dynamic envelope constraints of 31 cm in diameter and 26 cm in height. Given these mass and size constraints along with the limited resources of a university satellite project, some design limitations were placed on the spacecraft:

- In order to reduce mass and complexity, which increases failure risks, the number of deployable systems was to be kept to a minimum. In particular, deployable solar arrays were not considered as an option, and power was to be provided exclusively by body-mounted arrays.
- Given the reduced power output from the small arrays along with the severe mass and cost constraints, active control systems were eliminated from the design.
- Given the strict mass constraint, innovative approaches had to be considered for structural design, including extensive use of composites.
- Due to the cost and mass of commercially available attitude-determination systems, it was decided that a low-cost student-designed attitude-determination system would be developed. Such a system could not guarantee great accuracy, hence the satellite should be able to perform its mission with limited attitude knowledge.

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Given these constraints, the mission and final design of ASUSat 1 were dependent on the launch orbit provided by OSC. Launch availability changed three times since the program began, requiring four missions and satellite designs.

The initial design was based on a 450-km-altitude, 6:00 am - 6:00 pm, sun-synchronous orbit. In this orbit, the scientific mission was to measure the flux, mass, velocity, and temperature of microparticles in low Earth orbit. The scientific instrument developed by the students, the Micro Particle Recognition Experiment (MRE), incorporated the use of a thin, piezo- and pyro-electric polyvinylidene fluoride (PVDF) film to characterize interplanetary dust and microparticles (1). The spacecraft design included a gravity-gradient boom for stability. After the preliminary design of this spacecraft was completed, the available orbit changed.

The new launch opportunity was a 325-km-altitude, 6:00 am - 6:00 pm, sun-synchronous orbit. Unfortunately, the PVDF film in the MRE would be quickly eroded by atomic oxygen at this lower altitude. Hence, a new experiment had to be developed. At this stage of the design, few components were completed and a significant redesign was still possible without large increases in cost. The new mission involved the study of the ionospheric plasma environment found in the highest layers of the atmosphere. The Ionospheric Plasma Research Experiment (IPRE) (2) involved the measurement of plasma flows and the effectiveness of Hall accelerators using the atmospheric plasma. In addition, the design incorporated two CMOS (complementary metal-oxide semiconductor) cameras for earth imaging which would also be used as a secondary means to determine spacecraft attitude (3). The large aerodynamic forces associated with the atmospheric density at the lower altitude prevented the use of the gravity-gradient boom for stabilization, and an innovative stabilization system was developed to maintain proper orientation of the scientific instruments.

This design had to be abandoned when the launch was moved again, this time to a 550km-altitude, 10:30am-10:30pm, sun-synchronous orbit. Ion densities at this altitude are not sufficient to run the IPRE

effectively. At this point, the development of the spacecraft was in a very advanced stage and some of the most important components, such as the composite structure, were already built. The decision was made to reduce the scientific scope of the mission to Earth imaging and the demonstration of our low-cost satellite technologies, along with the Amateur Radio voice repeater. This new scientific scope required replacing the previous cameras with two higher resolution units. This design allowed for a vehicle able to perform in a variety of orbits, thus reducing risk if further changes in the launch opportunity developed.

In Fall 1996, the launch was changed again. The new plan is for ASUSat 1 to be the tertiary payload on a Taurus rocket. With the modular philosophy implemented in the previous design, ASUSat 1 did not have to change much for the new orbit of 778 X 790 km and inclination of 108 degrees. This latest version of the satellite is the one described in detail in this paper.

ASUSat 1

The mission of ASUSat 1 is one of technology demonstration and Earth imagery, along with Amateur Radio operations. ASUSat 1 has several innovative, low-cost aspects incorporated into its design. This includes two terrestrial cameras, monocoque composite structure, terrestrial GPS (global positioning system) unit; and student-developed array of attitude-determination sensors, small gravity-gradient boom-deployment mechanism, gravity-anchored passive spherical fluid damper, and electronics boards.

Structure

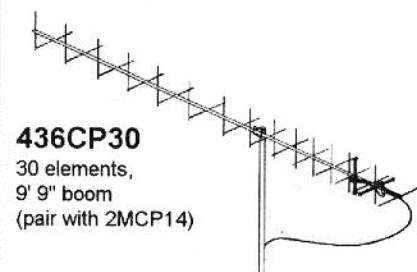
In order to meet the low-weight constraints on ASUSat 1, the satellite body is fashioned from a low-cost, light-weight carbon fiber in a 954-2A cyanate resin manufactured by ICI Fiberite Composites. The composite has 12 layers with 0°, 45°, -45°, and 90° plies. The total structural weight is 1100 grams, which includes epoxies, fasteners and aluminum brackets. The main bus structure is a 14-sided cylinder inscribed within a 31-cm-diameter circle, with a height of 24 cm, and wall thickness of 0.8 mm. This extensive use of composite materials presents some uncertainties in the analysis of the in-orbit thermal behavior of the satellite, since experience with composites in

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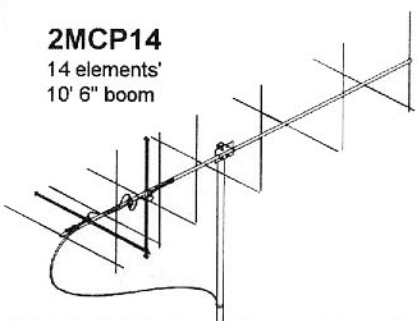
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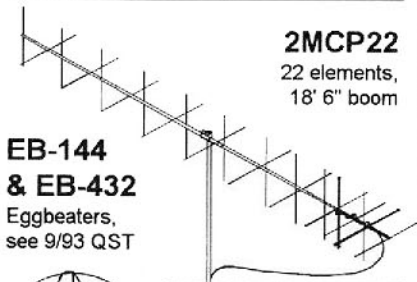
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(pair with 2MCP14)

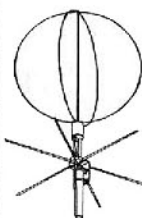


2MCP14
14 elements'
10' 6" boom



2MCP22
22 elements,
18' 6" boom

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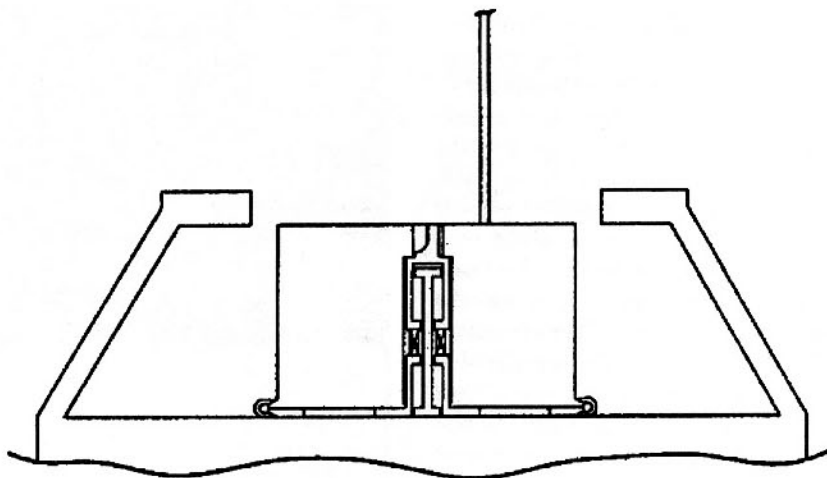


Figure 1. Deployment interface.

spacecraft applications is limited. In order to address these uncertainties, ASUSat 1 incorporates a number of student-designed thermal sensors which will provide an accurate thermal picture of the spacecraft. These data will be valuable to validate currently available thermal computer models.

The structure consists of several sub-assemblies designed for ease of fabrication. This is an important issue since students, with limited manufacturing experience, will build the satellite. The sub-assemblies include: the 14-sided main body; the removable top bulkhead, mounted flush with the top end of the satellite, the permanent science bulkhead, which is recessed 4 cm into the lower side of the spacecraft; two removable interior instrument and board mounting panels placed between the two bulkheads; the fixed deployment guide rod tube running through the center of the satellite, and brackets at

various angles to mount all sections together. The various components are assembled using a combination of space-grade epoxies, aluminum standoffs and stainless steel bolts. The satellite is attached to a student-designed deployment mechanism, which can be easily mounted to an interface plate in most launch vehicles.

Deployment

The deployment mechanism was developed to safely eject ASUSat 1 from the payload adapter cone section above the avionics of the Pegasus rocket (Figure 1.). This system was also designed to provide reliable deployment and a simple interface when used in other launch vehicles. This flexibility is important for future ASUSat missions given the limited resources of a university program. The deployment mechanism did not have to be modified with the change of launch to the Taurus mission.

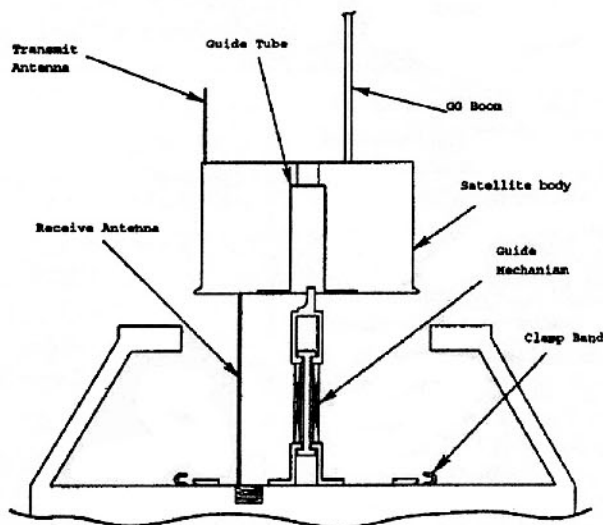


Figure 2. Deployment.

The satellite-deployer system consists of the following components: an extending guide mechanism running through the center guide tube in the satellite; a separation spring located in the guiding device; a clamp band to secure the satellite during launch; a bolt cutter; and a base plate to mount the system into the launch vehicle.

The deployment sequence begins with a pyrotechnic signal to the boom deployer. This guarantees that the satellite is deployed in a stable configuration. This is particularly important for ASUSat 1, since there is not any active attitude-control system present. After a 15-second delay, a second signal activates the deployment bolt cutter. This releases the clamp band, which is pulled away by retraction springs. The separation spring pushes the satellite out of the payload adapter cone section above the avionics at about 0.5 m/s, and the antennas automatically deploy after the spacecraft separates from the guide rod (Figure 2).

Dynamics & Control

The satellite uses gravity-gradient stabilization with a boom extended from the satellite top. The student-designed boom deployer is based on currently available systems, but has been miniaturized to fit within a 8 x 5 x 5 cm volume. This mechanism deploys a 2-meter beryllium copper element with a 130g copper tip mass.

A passive damper is included in the design to eliminate oscillations on the satellite due to possible deployment misalignments or external disturbances. The damper is a gravity-gradient-anchored system (4). In this device a gravity-gradient-stable mass is suspended inside a fluid. Given the near-polar orbit of the satellite, this passive damping system is superior to traditional magnetic dampers. In addition, if the mass is designed to be 3-axis stable, the system can provide 3-axis damping. The presence of the passive damper results in a much better imaging platform for the cameras. This gravity-anchored damping mechanism is one of the innovative technologies being tested on ASUSat 1.

A commercial (non-space-rated) GPS unit from Trimble Navigation provides position and velocity information. Modifications to the GPS receiver were performed by the students to improve its resistance to shock and vibration. The unit has been successfully

tested to flight qualification levels, and software corrections will be incorporated to remove the COCOM altitude and velocity restrictions.

A low-cost array of student-designed light-sensing diodes is used for attitude determination. A block of four diodes is mounted onto each of the 14 sides of the satellite. Three of the diodes sense visible light from the sun and one senses infrared radiation from Earth. Two more visible-light-sensing diodes are mounted on each bulkhead. All 60 sensors are read periodically to determine the orientation of the satellite. It is estimated that these sensors will provide attitude knowledge with an error of less than 10°. During the mission, Earth images from the cameras will be used to accurately calibrate the sensors and determine a more precise error estimate.

Imaging System

The imaging system on ASUSat 1 consists of two Dycam cameras and boards, one for color and the other a 256 grayscale. The cameras are mounted on the bottom bulkhead and provide overhead pictures of the Earth. Both cameras connect to the commands board by a serial link. One of these cameras incorporates a red and near infrared filter while the other camera has a blue filter. Each 50k compressed picture can be stored on the camera board in the 1 megabyte of flash memory. The cameras have a 496 X 365 pixel array with a an18 degree field of vision and a resolution of about 0.5 km per pixel. Image targets are open to the scientific community and all images will be posted and available for public use on the world wide web. Images will also be made available to ham radio operators worldwide.

Electronics

The CPU is designed around the Intel 80C188EC embedded microprocessor. The board has a 2-kb PROM for boot-loader software, a 256-kb EPROM where spacecraft-operations software is stored, and 1 Mb of RAM with a two-bit error detection and one-bit correction system. The CPU will initiate power-switch control for the power board, connect to a Zilog Z85230 HDLC controller for digital communication, and interface directly to the GPS board.

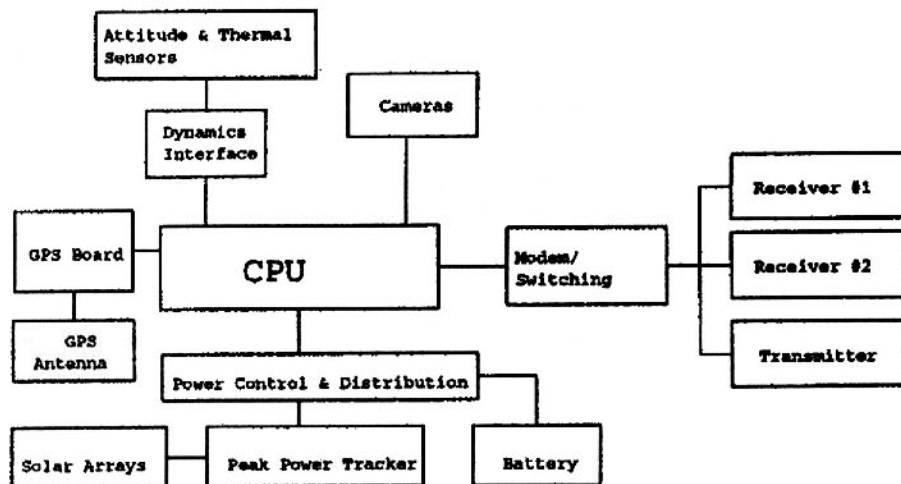


Figure 3. Control block diagram.

Analog measurements from the attitude-determination and thermal sensors are handled by a separate dynamics-interface board. This board is mounted directly on top of the commands boards and is connected by a serial link.

The satellite carries a total of 10 printed-circuit boards, plus 16 attitude-sensor boards. Four of the boards, along with the attitude sensors, are completely student designed. A block diagram of the satellite control boards is shown as Figure 3.

Power

The power system consists of the solar arrays, two six-packs of Nickel-Cadmium (NiCd) batteries, and associated control electronics.

The solar cells are space-rated Gallium-Arsenide (GaAs) cells with 18.5% efficiency. They are body mounted on all 14 sides and the top bulkhead. Each of the 14 side-panels contains two 15-cell panels. Six additional 15-cell panels are placed on the top bulkhead. Approximately 13 volts are provided from the 34 panels in parallel. This system will provide an average of 8 to 12 watts depending on solar-array temperatures and attitude.

The batteries will provide backup power in high-power-demand situations and during eclipses. The two packs will be used one at a time during the mission. Each pack provides 7.2 volts to DC-DC converters. Battery recharging is controlled by three peak-power trackers. However, they do not

provide enough power to run all systems during the 36-minute eclipse associated with the current orbit. The satellite will be placed in a low-power mode during eclipses. In this mode, in order to prevent the loss of software and data stored in RAM, only the CPU is on-line. In addition, critical systems, such as the transmitter and receiver, are kept warm to prevent temperature damage.

The power system is activated by the release of two redundant push-button switches upon deployment of the satellite.

The batteries are the heaviest component on the satellite, while the solar cells are the most expensive.

Communications

The communications system consists of a modem/switching board, partially designed by students, a RM753 transmitter and two receivers. The RM753 is a Maxon unit modified to work in the 420 to 440 MHz range. The receivers are Motorola P-50 Radius Radio transceivers modified by the students with support from Space Quest for use in the space environment.

ASUSat 1 is an amateur-class satellite operating in Amateur Radio band frequencies. AMSAT has concluded that ASUSat 1 does qualify as an Amateur Radio Satellite and it will be operated in compliance with all the rules covering Amateur Radio Satellites. The transmission frequency is in the 70-cm band, while the two receivers operate at separate frequencies within the 2-meter band. One receiver is used for digital mode. The second receiver

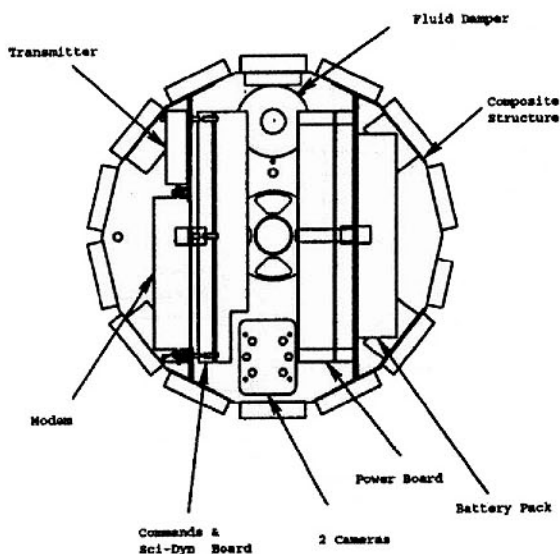


Figure 4. Inside view.

handles Amateur Radio voice communications and acts as a backup for the digital system. The modem operates at 9600 baud and interfaces with the CPU using HDLC-frame protocol.

The two receivers are enclosed within a thin aluminum mesh along with the GPS board for electromagnetic interference (EMI) protection. The layout of all internal boards is shown in Figure 4. The antennas are simple carpenter's-tape segments. They are mounted in a vertical position as shown as Figure 5.

Software

The software is designed around the BekTek Spacecraft Operating System. This

operating system offers a real-time multi-tasking kernel, a message-passing facility, AX.25 protocol drivers, and a set of DMA/Interrupt-based I/O drivers designed for the Intel 80C188 microprocessor.

Within this powerful operating system, there are six applications running concurrently during the mission. These applications control all on-board operations and measurements. The modules are the watchdog timer, the attitude determination, power, science, thermal, and communications software modules, and the bootloader module.

The software system is designed to receive ground commands to run the imaging and GPS systems at desired times. Other

operations, such as Amateur Radio voice communications, are controlled automatically depending on the power available. In addition, several onboard parameters, such as the time between thermal and attitude-sensor readings, can be easily modified from the ground.

Thermal

Temperature transducers are mounted on the CPU, battery box, transmitter, receiver mesh, and modem to monitor operation temperatures. The transducers on the CPU, transmitter, and modem are designed into the boards. If the temperature of any system exceeds operating limits, safety features in the software will turn the system off to prevent damage. Additional sensors are placed on the inside walls of the composite bus to monitor the thermal behavior of the composite material in the space environment.

Silverized Teflon is applied to all exposed surfaces of the structure to help reflect radiation. In addition, a black thermally conductive paint is used on the interior of the satellite to ease passive thermal control.

System Integration

Integration of all subsystems into the final satellite system is handled by the systems team. Cross-subsystem communication and design is also monitored to ensure optimization of weight, volume, power, functionality, and construction process. Assembly and test procedures are handled by a combination of the systems team and ground support, and EMI shielding is dealt with by all subsystems designing printed-circuit boards.

Currently ASUSat 1 is scheduled for delivery at the end of July and launch in August 1997. The development structure and systems are going through the final stages of testing. Most of the components are complete and the qualification prototype is scheduled for completion in early May 1997. This system will go through full qualification testing during May, and the final vehicle is scheduled for construction immediately following qualification testing.

Conclusion

The small satellite is an important training tool for the next generation of space scientists and engineers. The ASUSat 1

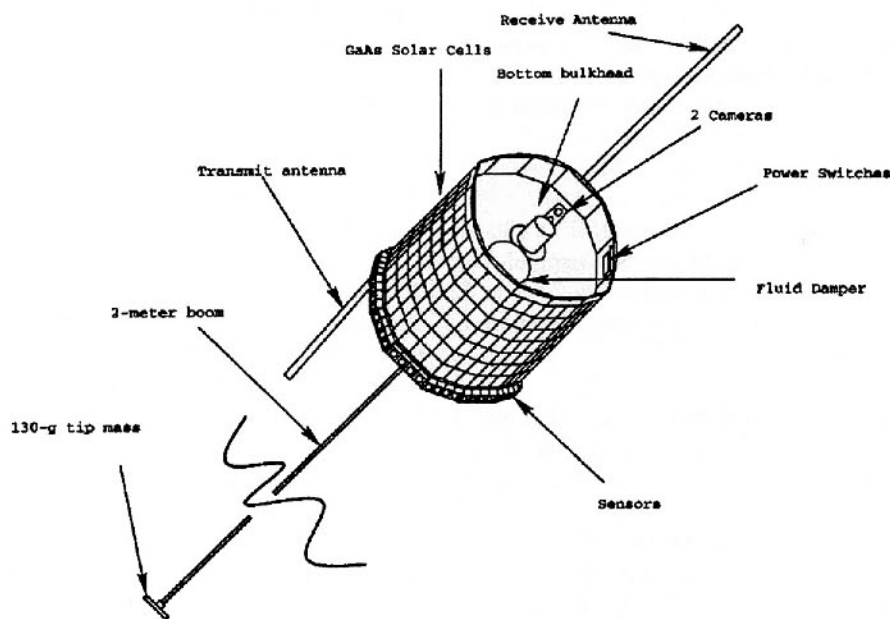


Figure 5. Complete configuration

project has provided over 250 students with hands-on experience in a real space program. They have participated from the initial concept, through the design and instrumentation, and will participate on through flight, ground operations, and data collection. The result is an intricate package of low-cost, light-weight, student-designed electronics and mechanisms that function as a complete system.

This system is also an important research endeavor. A variety of innovative solutions have been developed to meet the challenge to design and construct an advanced and innovative nanosatellite within very severe constraints on mass, size, and budget. The resulting spacecraft (ASUSat 1) incorporates a variety of innovative technological features: all composite structure, student-designed low-cost attitude-determination system, terrestrial components which were space-rated by the students, low-cost cameras, and so forth.

The future of interplanetary exploration must be based on the development of lower-cost missions, and the design philosophy applied to ASUSat 1 can help provide the fundamental change required to create the next generation of interplanetary nanosatellites. Cost and launch mass are determined first and a meaningful scientific mission is chosen which fits those constraints. In the spirit of this philosophy, then, the space community should be challenged to produce a valid scientific mission with seemingly impossible mass and cost constraints. The ASUSat 1 team feels that this is the kind of challenge required to provoke the fundamental change necessary to continue the exploration of the solar system in the 21st century.

Acknowledgments

We would like to thank all students involved with the ASUSat 1 project since its conception in October 1993. Many thanks also go to Scott Webster (OSC), Rich Van Riper (Honeywell Space Systems Group), and all other faculty and industrial sponsors. Without their help this project would not have been possible. We especially thank the students from the Machine Trades Program at Maricopa Skill Center (a Division of GateWay Community College, one of the Maricopa Community Colleges) for building low-cost on-board components.

The Radio Amateur Satellite Corporation (AMSAT) has provided advice regarding the ASUSat spacecraft design, as well as guidance regarding its qualification to be treated as an Amateur Radio Satellite. Frequencies have been coordinated through the IARU Amateur Satellite Frequency Coordinator Graham Ratcliff, VK5AGR.

Donations and support have been provided by organizations and companies throughout the Phoenix metropolitan area and the nation. Orbital Sciences Corporation has donated the launch, advising, and test facilities. The ASU NASA Space Grant & Fellowship Program has provided both student internships and fellowships. The National Science Foundation Faculty Awards for Women in Science and Engineering has also provided student funding. Honeywell Space Systems Group provided advising in all areas of the project and a cash donation. Intel's University Support has donated several 80C188 processors, support literature, an In-circuit emulator, and other test equipment. Motorola's Satcom and University Support provided technical advising for thermal, power, and communications systems, and donated several IC's and crystals for the command board, as well as three P-50 transceivers for communications. Hughes Missile Systems provided advising, electronics trouble shooting, use of facilities, and a cash donation. Others that have provided technical advising and support are:

- Space Quest: communications advising and support
- Dycam: on-board cameras
- PhotoComm, Inc.: solar array advising and facilities
- Eagle Picher Industries: advising (battery algorithm), batteries
- Maxon: donation of flight transmitter boards
- Universal Propulsion Company, Inc.: advising, explosive bolt cutter donation
- ICI Fiberite Composites: advising, composite material
- DynAir Tech of Arizona (now SabreTech): advising, autoclave usage, composite material, facilities for manufacturing parts
- National Technical Systems: environmental testing
- SpectrumAstro: communications testing
- Trimble Navigation: GPS board and antenna, advising
- Bell Atlantic Cable: ground station antenna cabling

- Lee Spring Company: prototype deployment springs
- Astro Aerospace: advising, boom material donation
- BekTek: software advising
- Jet Propulsion Laboratory: non-flight transmitter donation
- Rockwell: non-flight solar-cell donation
- Sinclabs, Inc.: non-flight test antenna donation
- Applied Solar Energy Corporation: discounted hardware, advising
- Gordon Minns and Associates: on-board cameras
- Simula, Inc.: structural-analysis advising
- KinetX: advising on software and ground support
- Equipment Reliability Group: advising on testing equipment
- Arizona State University: hardware funding
- ASU/Architecture & Environmental Design Shop: machining facilities
- ASU/Center for Solid State Electronics Research: clean-room advising, use of equipment and lab space
- ASU/Telecommunications Research Center: use of anechoic chamber
- ASU/Electrical Engineering Department: loan of testing equipment

Additional information on the ASUSat 1 design can be obtained on the World Wide Web at:
<http://emws229.eas.asu.edu/asusat/asusat.html>

Plus, the ASUSat team is featured as the cover story in *Graduating Engineer* (from Peterson's Magazine Group), Volume 18, Issue 1, September 1996.

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Proposal: An AMSAT Mobile TRAKNET

by Bob Bruninga, WB4APR,

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Commercially, there are two distinct advantages of the global nature of satellites which cannot be easily met with terrestrial systems: wide-bandwidth point-to-point and mobile applications. With the availability of telephone, cable, and the Internet to link amateurs at fixed sites to each other routinely, we are wasting a lot of potential of our very valuable Amateur Radio satellite resources by ignoring mobile applications.

Ham radio is on the move. Any survey will likely show that many amateurs only have time to play radio while mobile, and similarly, whenever a ham contemplates a long trip, his ham radio is high on the packing list. Although many dream of taking along an HF mobile to play with and to report their progress back home, the \$1000 to \$2000 investment is just too much of a risk. Two meters is fun, and can bring emergency aid, but it just doesn't provide the nationwide coverage that is needed for the mobile ham traveler far from home, the offshore boater, or first-response teams arriving in a disaster area. In many cases, just a brief position/status report is all that is needed to assure the health and welfare of the traveler or to summon assistance or alert other communications channels.

Many hams have put together impressive mobile satellite stations, but the performance is poor and takes a major investment in dollars, size and weight. The reason is that they are essentially duplicating a typical weak-signal home satellite station on wheels. What we need is a new perspective which takes advantage of some very unique capabilities to exploit a small portion of our satellite on-orbit capacity to the mobile requirement. Fortunately, there are several Amateur Radio satellites that are *very easy* to transmit to from the mobile using only a 2 meter 25 watt FM mobile radio - the ubiquitous radio that *everyone* has.

Uplink

Lets look at the 1200 baud Pacsat uplinks. These uplinks are unique for several reasons that make them ideal for the mobile environment:

- The 2-meter uplink from a mobile omni antenna has a 9 dB advantage over a similar 435 MHz link due to the three times larger antenna aperture.
- There is no tuning or tracking required on the uplink since the Doppler on 2-meter is less than 3 kHz.

- Any 25 watt mobile 2-meter FM rig can be used as the transmitter.
- Any TAPR-2 compatible TNC can be modified for the uplink for \$2.
- World-wide coverage.
- *No* software or hardware on-orbit modifications to the satellite.

Reportedly, stations running as low as seven watts into an indoor omni antenna have reported success with the 1200 baud PACSATS. This means that even backpackers with an HT and handheld gain antenna could get emergency or priority traffic into a Pacsat from anywhere on Earth! Figure 1 shows the results of the SPRE experiment during STS-72 when there was a digipeater on the Shuttle for station position/status reporting.

Downlink

OK, so the 2-meter *uplink* is easy and anyone can do it, so what about the downlink? This is not so easy. The path loss omni-to-omni is 9 dB worse, the satellite is only transmitting a watt or so for another 13 dB worse performance, plus it *requires* Doppler tuning, a \$250 PACSAT modem and a \$1000 all mode UHF receiver! In most cases, all successful Pacsat stations use high gain antennas and automatic tracking to make up for the more than 22 dB performance difference on the downlink. This is not something that most operators will want to add to their mobile. But what if the mobile application did not need to receive data, but only send it?

Traknet

The combination of *easy* uplinks, *minimum* downlinks, and an application that often only needs a one way exchange of data, such as the mobile position/status report is the whole idea behind Traknet. Only a few automated downlinks are needed every 1000 miles or so to receive the mobile data and to provide it into a nationwide system of linked ground stations. These ground stations relay the mobile position/status reports onto local mobile vehicle tracking channels and onto the Internet. Anyone may access these data live on VHF, HF or via the Internet. Traknet is not just a future idea, it can be implemented immediately with existing equipment and satellites. Yes, even the

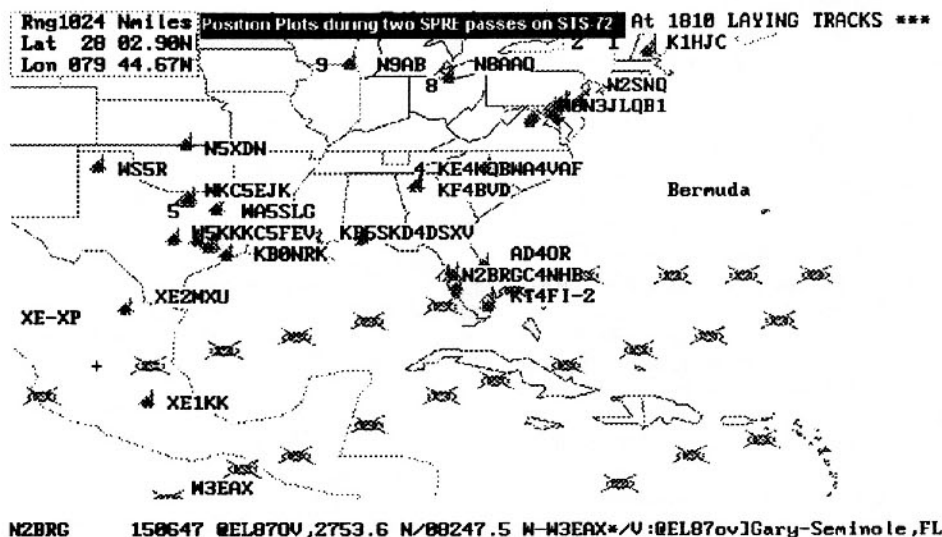


Figure 1. This figure shows the display of stations in the US that successfully digipeated their positions and status via the SPRE experiment on STS-72. A similar experiment was conducted via SAREX on STS-78.

Internet ground stations exist. Already there are six Traknet-type stations on the World-Wide-Web. Just link to any of the following sites and you will see *LIVE* (or nearly live) fixed and mobile amateur radio position/status reports.

- ATLANTA: <http://www.wadysy.radio.org/aprs/index.html>
- CALIFORNIA: <http://sboyle.slip.net.com/LIDSAPRS.html>
- CHICAGO: <http://tbcnet.com/~jleonard/noiltest.html>
- MIAMI: <http://www.bridge.net/~sdmse/javAPRS.html>
- ONTARIO, CANADA: <http://www.peel.com/javAPRS.html>
- WASHINGTON, DC: <http://web.usna.navy.mil/~bruninga/aprs.html>

You only need to access one, since most of them have links to each other, and more are coming on line monthly. Some of these sites are already listening to many such status/position reporting channels. But the problem is that none of these sites is yet listening to the Pacsats mostly because setting up an automatic Pacsat ground station is not trivial and the guys who play with the Web all day are not the same guys that are necessarily fully invested in Pacsat hardware. All we need are probably eight stations scattered over the continental USA to implement a reasonable Traknet system as shown in Figure 2.

Mobile Station

A mobile station consists of nothing more than a typical 2-meter FM radio and a modified TAPR-2 compatible TNC as shown in Figure 3. Optional accessories are

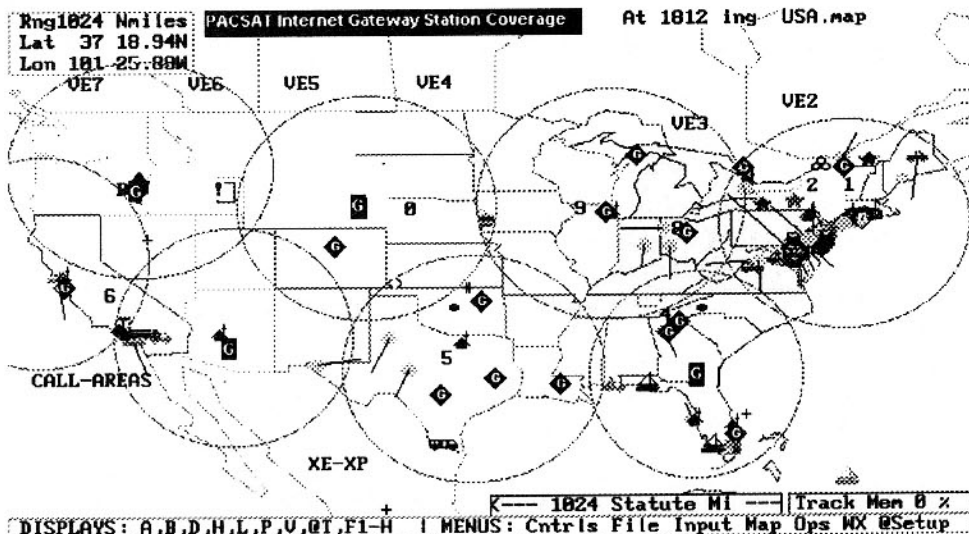


Figure 2. This figure shows how eight reasonably located PACSAT Internet Gateway stations could provide nationwide coverage for mobile travelers. These range circles are a very conservative 600 mile radius or less. Two hundred or more mobiles could be accommodated per footprint per pass.

a GPS for moving position reports, and a laptop for entering messages. Most modern TNCs will accept the GPS data directly and will transmit the data in a timed packet burst. There is even a tiny handheld TNCs called the APRS Mic-Encoder that includes front panel switches for selecting 1 of 7 pre-canned status messages without needing a laptop to change the status report. The modifications to the TAPR-2 TNC are to simply **exclusive or** the transmit data with its 1200 Hz clock and to filter the result to the Mic input of the radio. The following circuit will do this with nothing but an 89 cent standard 7400 quad 2 input NAND gate connected as an XOR gate to the two points shown.

The pin numbers shown in Figure 4 are for a PacComm TINY-2.

Traknet Protocol

The problem with any Amateur Radio satellite is the very low bandwidth available compared to the very large worldwide Amateur Radio population. At first glance, the prospect of increasing the number of users on a Pacsat channel by a hundred fold raises lots of red flags in the minds of those stations who already find ten minutes of a satellite pass to be too short for any meaningful dialog. But what if each of these hundreds of new users was limited to only a few seconds per orbit? Then as many as 200 stations per footprint could be tracked. That is the only objective of the Traknet protocol, to allow everyone to transmit a few single 1 second position/status reports during the closest point of approach over their location. If only one channel is designated for Traknet,



Figure 3. This photo shows a typical PACSAT mobile status/position reporting station. It consists of a 2 meter FM radio, a GPS unit and a slightly modified TAPR-2 compatible TNC.

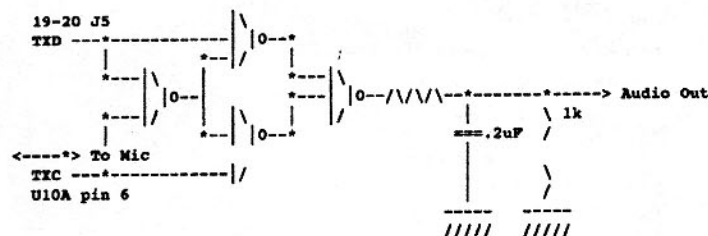


Figure 4. Pin numbers for a PacComm TINY 2.

then the other 3 channels are free for normal Pacsat use and no amount of congestion on the Traknet channel can interfere with existing users on the other three.

Traknet Satellites

There are currently five 1200 baud Pacsats on orbit. One, WO-18 has actively invited UI frame digipeating and leaves DIGIPEAT on most of the time. The problem is that the WO-18 downlink is difficult to receive unattended due to a spur tone in the middle of the data which makes receiver lock a difficult and manual process. AO-16 has had its digipeater ON for the last six months. Other Pacsats occasionally have DIGIPEAT turned on, but there is no formal policy. The purpose of this article is to encourage the designation of one good channel as a gathering point for Traknet experiments, and then progress can be made and the potential of Traknet can be evaluated. Here are the frequency plans of the existing Pacsats:

Digipeater	Uplink (MHz)	Downlink (MHz)
AO-16	145.860, 145.900, 145.920, 145.940	437.051
LU-19	145.840, 145.860, 145.880, 145.900	437.153
WO-18	145.900	437.104
IO-26	145.875, 145.900, 145.925, 145.950	435.822

Advanced Mobiles

While the preceding was written to emphasize the ease of using the Pacsats by anyone for emergency or priority status/position reporting, there is certainly no reason why a full two way Pacsat communications system cannot be added to most mobiles. Omni Pacsat downlinks are possible and the addition of only a modest gain antenna will certainly help. Advantages are the small size of a 6 dB two element UHF antenna and the SHORT cable run found in a mobile. Rather than a \$1000 SSB rig, a \$90 QRP HF rig and a UHF downconverter could do just as well.

Conclusion

The advent of the handheld GPS unit for under \$199 has brought thousands of mobile

amateur radio operators into the world of mobile data. For years, the growth of amateur GPS applications have been growing at phenomenal rates. At this writing there are mobile map packages available which *include* the GPS unit for under \$150 total! Similarly, the state-of-the-art in automatic Pacsat ground station technology has been improving with many recent software packages to make un-attended automatic ground station operation quite easy. The problem is that these two communities of expertise have so far had little cross-interests. It seems that the time is now to merge these technologies into a new amateur application that takes advantage of the unique capabilities of each and fuels the development of an Amateur Radio Mobile Satellite System. Traknet is the opportunity to not only merge these interests into a common purpose, but also to demonstrate Amateur Radio's continuing progress in communications technology. ■

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Field Ops Update: Dayton Hamvention and Workshops

Barry A. Baines, WD4ASW, wd4asw@amsat.org

Area Coordinators play a significant role in showing the flag for AMSAT by fulfilling the role of running the AMSAT booth at local hamfests. A number of folks have unfurled the AMSAT banner at places like Miami, Orlando, Lincoln, NE, Lafayette, LA, and Baltimore, MD. The efforts of these coordinators ensure that amateurs are kept informed of the status of our satellite program (such as Phase 3D) and perhaps pick up some information on how to get on the satellites. Hamfests allow fellow AMSAT members to greet one another, share the latest information, and perhaps learn a thing or two from one of the experts. Finally, AMSAT's presence at local hamfests provides an opportunity for area coordinators to publicize the existence of our field organization and let newcomers to the satellite program learn of the potential for finding assistance from our field organization.

The biggest hamfest of all will once again be happening in Dayton, OH this Spring. The Dayton Hamvention takes place May 16-18 at Hara Arena. (Given its significance, calling Hamvention a *hamfest* is like calling the World Series a *baseball game*. There is nothing that matches its commercial exhibit and flea market size, variety of forums, and ability to attract amateurs from around the world.) This will be the second year that Hamvention occurs in May; last year's event was blessed by great weather compared to rainy weekends when held in April. Let's hope the trend continues.

AMSAT will have a major presence at the Hamvention and every AMSAT member who attends is certainly invited to stop by the booth. We will be at the same location as previous years: Booth spaces 445-448. Martha and company will have the latest AMSAT materials available for an appropriate donation; you can also use this opportunity to check on your membership status and renew.

AMSAT will be involved with presentations during each of the days of the Hamvention. A Beginner's Presentation will be given Friday afternoon; at press time it is scheduled to start at the same time as the commercial doors open (1200 EDT). Check the Hamvention Program for location and confirmation of the presentation time. This

one hour forum is designed specifically for folks who are not familiar with the satellite program and will provide information on where to get help and what resources are available about the Amateur Satellite Service. If you know of anyone who would be interested in this material, let them know of the forum in advance since it will indeed start just as the commercial doors are opening.

Phase 3D and Manned Space will be covered during a Saturday afternoon forum (1245-1345 hrs). Learn the latest status of Phase 3D and how preparations are proceeding for launch from members of the Phase 3D Team. In addition, Frank Bauer, KA3HDO, AMSAT Vice President for Manned Space Program, will moderate a discussion on SAREX and preparations for Amateur Radio on the International Space Station. Past presentations on Saturday have been standing room only and this year's discussion should be just as popular.

At 0900 on Sunday morning, Ed Krome, K9EK, will give a talk on getting ready for Phase 3D. This should be a popular topic, as Ed will outline ground station considerations and provide tips on how to take advantage of Phase 3D's variety of bands and modes.

As noted above, check the Hamvention Program for specific location and times for these programs. As you can see, AMSAT will be making a major presence at Dayton. If you are at Dayton, please stop by the booth and say *hello*. Keep in mind that our traditional Friday night social gathering will take place at the Amber Rose Restaurant in Old North Dayton; this is the same place as last year. Look for announcements via amsat-bb and AMSAT News Service about reserving a seat and updated information.

AMSAT/ARRL Satellite Workshops

I've mentioned in earlier columns the developing trend in providing ARRL/AMSAT sponsored satellite workshops, where people can attend a five hour class on the amateur satellite program and learn the basics of satellite communications. During these sessions, participants learn about the various satellites, equipment requirements and setup, where to find information, and operating procedures and hints. The first workshop of 1997 was

held on January 31 in conjunction with the Miami Hamboree and was attended by 31 registrants, including attendees from Latin America and the Caribbean. Thanks to Bob Walker, N4CU, John Kuklinski, N4PLY, and Bruce Burke, WB4UYC for helping to make the workshop an outstanding success.

The next workshop will be held June 13 in Seaside, OR in conjunction with the SeaPac Convention. This workshop leader is Ed Krome, K9EK. As this workshop is scheduled during the same period as final preparations for launch of Phase 3D are expected to take place, interest in the amateur satellite program will be high. As of mid-April there were over 80 people already registered for this workshop! If you know someone who might be interested in attending this workshop, have them contact Rosalie White, WA1STO, at ARRL Headquarters (telephone 860-594-0237 or fax 860-594-0259) to reserve a slot. Registration fee is \$20.00 for ARRL members and \$25.00 for non-ARRL members. Those who take part in the entire workshop will earn a certificate for 0.5 Continuing Education Units.

Presentation Materials Now Available

For those with Web access, you might want to take a look at the AMSAT WWW site and download a variety of presentation materials that are now available. For example, Ed Krome's presentation on Phase 3D Ground Station requirements given at Hamvention 96 and updated for the AMSAT Symposium last October is currently available. Various formats of K9EK's presentation can be found at ftp.amsat.org/amsat/presentations/phase3d. In addition, a number of presentations for beginners in PowerPoint format (.ppt) are also available. These cover a variety of subjects, such as the Easy Sats, satellite tracking, and digital satellites. These can be found on the ftp site under ftp.amsat.org/amsat/presentations/new. Copies of the *Amateur Satellite Resource Guide* by Gary Rogers, WA4YMZ, as well as his booklet *Working the Easy Sats* are also available on the AMSAT WWW site in two different formats and have been highlighted as one of the featured articles of the Web site. These are excellent materials that you can download. ■

A Loop Antenna for RS Satellites

Bob Johnson, W7LRD, w7lrd@amsat.org

I have been working with RS10, 12, and 15 for several years now. These three satellites have their downlink frequency in the upper middle portion of the ten-meter band. It did not take a lot of operating to realize that my four element quad, through a great antenna, was quite pitiful for receiving when the satellite was above 30 degrees in elevation. To solve the problem of working these RS satellites when above 30 degrees elevation, I use a loop antenna.

The loop antenna is patterned after my quad antenna, except that it is round and looks up (Figure 1.) Construction is quite simple; I used sunlight resistant half-inch PVC pipe with antenna wire inside it. The same formulae were used as with a quad. The formula for loop length (or circumference) is $1005/\text{Frequency MHz} = \text{feet}$. The impedance of a single loop is about 120Ω . I used RG-8, as it is what I had readily available. The purist can use a quarter-wave transformer to make a near perfect match, though the improvement would be hardly noticeable.

There is a PVC fitting that has an access cover where an SO-239 can be installed,

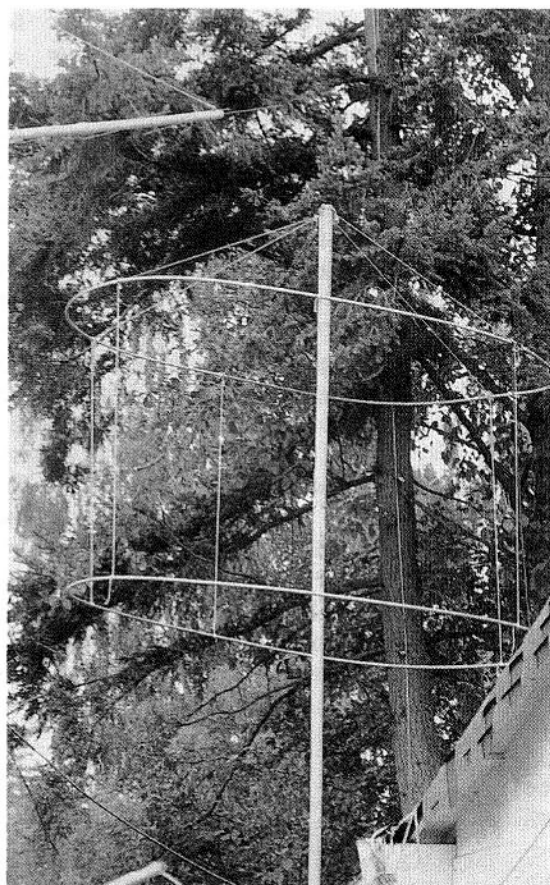


Figure 1. W7LRD's loop antenna. (Photo by Bob Johnson, W7LRD)

or the coax can be soldered directly to the antenna wire. After using the loop for a year or so, I tried hanging a reflector below the loop which then is essentially a two-element round quad looking up. The results were encouraging, particularly for RS-15 whose downlink signal is weaker because of its higher altitude. The length for the reflector (determined by $1030/\text{Frequency (MHz)}$) is six feet. Also the higher the antenna is mounted the better it seems to work. My loop is about 20 feet off the ground.

I have made direct comparisons of the single loop with a turnstile (crossed dipoles) antenna. The loop was always as good as and usually better than the turnstile antenna. Whether a single loop or two-element version is used, the receiving capabilities are improved as compared to a standard beam or dipole. With a satellite approaching I use my terrestrial beam until it reaches an elevation of 25 to 30 degrees. I then switch to my loop antenna for almost seamless reception.

While the antenna gets funny looks from my neighbors, it is inexpensive to build and needs only one support. You could even lay it on a roof. ■



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James Miller, G3RUH, g3ruh@amsat.org

Current Amateur Satellite Frequencies

Analog Satellites

Satellite	Beacon (MHz)	Uplink (MHz)	Downlink (MHz) ¹	Type
AO-10 ²	145.810 and 145.987 ³	435.030-435.180 LSB/CW	145.975-145.825 USB/CW	Mode B
AO-27	145.850 FM	436.800 FM	Part-Time Repeater	
FO-20 ⁴	435.795	145.900-146.000 SSB/CW	435.800-435.900 SSB/CW	Mode JA
FO-29	435.795	145.900-146.000 SSB/CW	435.800-435.900 SSB/CW	Mode JA
RS-10 ⁵	29.357	145.865-145.905 USB/CW	29.360-29.400	Mode A
RS-12 ⁶	29.408	21.210-21.250 USB/CW	29.410-29.450/145.910-145.950	Mode KT
RS-15	29.352	145.858-145.898 USB/CW	29.354-29.394	Mode A
RS-16	29.408 and 29.448	145.915-145.948 USB/CW	29.415-29.451	Mode A

Digital Satellites

Satellite ⁷	Name or Callsign	Uplink (MHz)	Downlink (MHz) ¹	Type
UO-11			145.825 FM	1200 Baud PSK
AO-16	PACSAT	145.900, .920, .940, .960 FM	437.0513 SSB	1200 Baud PSK
DO-17	DOVE		145.825 FM	1200 Baud AFSK
WO-18 ⁸	WEBERSAT		437.104 SSB	1200 Baud PSK AX.25
LO-19	LUSAT	145.840, .860, .880, .900 FM	437.1528 SSB	1200 Baud PSK AX.25
UO-22	UOSAT5	145.900, .975 FM	435.120 FM	9600 Baud FSK
KO-23	HL01	145.850, .900 FM	435.175 FM	9600 Baud FSK
KO-25	HL02	145.980 FM	436.500 FM	9600 Baud FSK
IO-26	ITMSAT	145.875, .900, .925, .950 FM	435.822 SSB	1200 Baud PSK
FO-29	8J1JCS	145.850, .870, .890, .910 FM	435.910 FM	9600 Baud BPSK

MIR and SAREX

Spacecraft	Callsign	Uplink (MHz)	Downlink (MHz) ¹	Type
Mir	ROMIR	145.200 FM	145.800 FM	Voice or Packet
Mir	ROMIR ⁹	435.750 FM	437.950 FM	Repeater
Mir	ROMIR ⁹	435.725 FM	437.925 FM	Voice
Mir	ROMIR ⁹	435.775-436.775@25kHz spacing	437.975 FM	9600 Baud Packet
Shuttle	W5RRR	144.490 FM ¹⁰	145.550 FM	Packet
Shuttle	Various	144.910, .93, .95, .97, .99 FM ¹⁰	145.550 FM	Non-Mir Docking Missions
Shuttle	Various	144.450, .470 FM ¹⁰	145.840 FM	Mir Docking Missions

Notes:

- 1) Frequencies are shown without Doppler compensation. At start of typical LEO pass, the original signal will be several kHz higher than shown. Refer to specific satellite operating instructions for complete details.
- 2) For AO-10 and AO-13 Mode B, transmit in LSB, receive in USB. Also in Mode B, when the transmitted frequency is increased the received frequency will decrease (inverting transponder). AO-10 is no longer controllable but the transponder works when the satellite is in sunlight.
- 3) AO-10 beacon is an unmodulated carrier. Do not transmit to the satellite if the beacon is FMing.
- 4) Presently, FO-20 digital JD mode is not operational.
- 5) RS-10 Robot via 145.820 MHz uplink and 29.403 MHz downlink.
- 6) RS-12 Robot via 21.129 MHz uplink and 29.454 MHz downlink.
- 7) Digital satellites use a program suite containing PB/PG/PFHADD/PHS or WiSP.
- 8) WO-18 transmit experimental and image data and can be captured in KISS mode via PB or TLMDIC.
- 9) Tentative frequencies for SAFEXII that are currently being tested. Refer to AMSAT News Services bulletins for additional information.
- 10) These are typical SAREX uplink frequencies. Refer to AMSAT News Service bulletins for exact SAREX frequencies.

AMSAT HF & VHF Voice Nets

Net Designation	Day	Time	Frequency (MHz)	Net Control Station
International:				
AMSAT International	Sunday	1900 UTC	14.282	W5IU
AMSAT International ¹	Sunday	1900 UTC	21.280	W8GQW
AMSAT International ¹	Sunday	2300 UTC	18.155	N4QQ
Regional (USA):				
AMSAT-NA East Coast	Tuesday	2100 Local	3.840	W8GUS
AMSAT-NA Mid-America	Tuesday	2100 Local	3.840	W5IU
AMSAT-NA West Coast	Tuesday	2000 Local	3.840	K6OYY/K7RR
Local:				
AR-LA-TX QCWA Net ²	Monday	1930 Local ³	146.670	WA9PZL
Boston Area SPOT Net	Friday	2130 Local	145.230	N1HID
Central NY AMSAT Roundtable	Monday	2000 Local	146.880	WA2EXJ
Central Ohio Sat Int Group	Tuesday	2000 Local	145.490	Various
Colorado AMSAT Net	Wednesday	2000 Local	147.225	N0VSE
Dallas/Ft Worth AMSAT Net	Wednesday	1945 Local	147.140	Various
Derry, NH AMSAT Net	Friday	2000 Local	146.850	K1MON
Detroit AMSAT Net	Thursday	2000 Local	146.760	N8ULU
Harrisburg, PA AMSAT Net	Sunday	2000 Local	145.210	KA3TKW
Houston Area AMSAT Net	Sunday	2000 Local	147.100 ⁴	W5ACM
Long Island, NY AMSAT Net	Tuesday	2000 Local	147.210	N2WWD
Portsmouth, NH AMSAT Net	Thursday	2000 Local	146.805	K1MON
Saco, Maine AMSAT Net ⁵	Sunday	2000 Local	146.775	K1MON
S.W. Ohio AMSAT Net	Tuesday	2000 Local	145.110	N8NPX
Tucson Area AMSAT Net	Wednesday	1900 Local	146.880	NW7N, AA7KC, KB7WFO
Waltham, MA AMSAT Net	Thursday	2030 Local	146.640	N1OHJ
Washington, DC Area Net	Sunday	2100 Local	146.835	N3KHK

Notes:

1. Nets suspended temporarily due to poor band conditions
2. NSC is in Shreveport, LA
3. 2000 CDT during summer
4. Simulcast on other ham frequencies and SBS 6, Transponder 13B, 6.2 GHz audio subcarrier. Contact NCS.
5. Linked with various repeaters. Contact NCS for frequencies.

1997 AMSAT Field Day Competition

Andy MacAllister, W5ACM
w5acm@amsat.org

Field Day is once again just around the corner beginning at 1800 UTC on June 28th for a 24-hour period. We are proud to announce the 1997 AMSAT Field Day Competition. It is open to all Amateur Radio operators. U.S. and Canadian amateurs are to exchange ARRL section and Field Day transmitter class. Foreign amateurs should exchange country name and signal reports. Last year's effort was very successful. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. This year CW contacts and digital contacts are worth three points as outlined below.

Here are the rules for the 1997 AMSAT Field Day competition.

1. Analog Transponders

- Each satellite transponder is considered a separate band.
- All phone QSO's and all CW QSO's on a given satellite transponder are considered separate bands.
- All packet/RTTY/ASCII/AMTOR QSO's through analog transponders are counted as CW QSO's.
- Phone QSO's count for one point and CW QSO's count for three points
- Cross-mode (CW-phone) contacts are not allowed.
- The use of more than one transmitter at the same time on a single satellite transponder is prohibited.

2. Digital Transponders

For the Pacsats (LO-19, KO-23, etc.) each satellite is considered a separate band. Do not post "CQ" messages. Simply upload one greeting message to each satellite and download as many greeting messages as possible from each satellite. The subject of the uploaded file should be posted as Field Day Greetings addressed to ALL. The purpose of this portion of the competition is to demonstrate digital satellite communications to other Field Day participants and observers.

The following uploads/downloads each count as a three point digital contact:

(a) Upload of a Satellite Field Day Greetings file (one per satellite).

(b) Download of Satellite Field Day Greetings files posted by other stations. Other non-Field Day files or messages not addressed to *All* are not to be counted for the event.

Satellite digipeat QSO's do not count for any score and the use of gateway stations to uplink/downlink is not allowed.

The MIR PBBS is not to be used for Field Day operations.

If FO-20 or FO-29 are active, the JA transponder can be used for analog CW and phone activities under the analog transponder rules, and the JD system can be

used as a separate transponder under the digital rules.

Sample Satellite Field Day Greetings File:

Greetings from N5EM Field Day Satellite station near Galveston, Texas with 24 participating members in the AMSAT-Houston group. All the best and 73!

Note that the message stated the call and name of the group, where they were located and how many were in attendance.

3. Operating Class

Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off Emergency or Commercial for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

The Satellite Summary Sheet (Figure 1) should be used for submittal of the AMSAT Field Day competition results to Andy MacAllister, W5ACM, Vice President User Services, 14714 Knights Way Drive, Houston, TX 77083-5640. Make sure to also send your Field Day photographs with your submission! Deadline for submissions is August 1, 1997.

Competition was tough in 1996 and should be even tougher in 1997. The station submitting the highest score for portable operation using emergency power will receive a plaque at the AMSAT Space Symposium and Annual Meeting to be held in Toronto on October 17-19, 1997.

We hope this event provides satellite operators with the practice necessary to set up a ground station and effectively operate via the satellites in an emergency situation. Remember that Field Day also provides a good opportunity to expose newcomers to the amateur-radio satellites. Most of all, it should be a lot of fun for all who participate.

GL ON FD ES 73,

Andy, W5ACM■

NOVA for DOS, Windows or new Windows 95: \$49.95. WinTrak Pro: \$69.95. SASI Sat Tracker: \$279.95. Freq. Mgr. (radio auto-tune for Doppler shift): \$65.95. SB-32 Mode S 2'X3' Parabolic Dish antenna for 2.4 GHz: \$55.95. Yaesu G-5400B Az/El rotor: \$526.95. Shipping extra on all. Dealer for all M2, Eggbeater and KLM antennas: Call for prices. OSCAR Satellite Report Newsletter: \$35 USA. Elsewhere higher. Special 8' Fiberglass boom, 1-1/2 inches solid: \$79.95. HF antennas and rotors, too! Call/write/email. Check our Web page.

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AMSAT Journal Telemetry

South Texas Balloon Launch Scheduled for July

The South Texas Balloon Launch 12 (BLT-12) is scheduled for Saturday, July 12, 1997 from the Texas coastal bend. BLT-12 payload will be a lifting body that will be released from 100,000 feet and will be flown to a ground landing. Presently, low-altitude tests are underway from the Fort Bend County Fairgrounds to assess the flying ability of the lifting body. Plans will be made for a high-altitude hot-air-balloon drop after a meeting to identify any needed repairs and

structural changes based on the tests. BLT-12 information can be obtained via the Houston AMSAT Net, held Tuesday 8:00 PM CDT on 147.100 MHz repeater in Houston or SBS-6 TR-13, 6.2 MHz audio subcarrier in North America. via Andy MacAllister, W5ACM.

1997 ARRL and TAPR Digital Communications Conference <http://www.tapr.org/dcc>

It's that time again! Time to mark your calendar and think about what to publish for

the upcoming 16th Annual ARRL and TAPR Digital Communications Conference. This is the second year in which the ARRL Digital Communications Conference and TAPR Annual General Meeting have joined into one conference! The ARRL and TAPR Digital Communications Conference is an international forum for radio amateurs in digital communications, networking, and related technologies to meet, publish their work, and present new ideas and techniques for discussion. Presenters and attendees will have the opportunity to exchange ideas and learn about recent hardware and software advances, theories, experimental results, and practical applications. The Digital Communications Conference is not just for the digital expert, but for digitally-orientated amateurs of all levels of experience.

The 1997 ARRL and TAPR Digital Communications Conference will be held October 10-12, 1997 in Baltimore, Maryland. This year's conference location is just minutes away from the Baltimore/Washington International (BWI) Airport.

Full information on the conference and hotel information can be obtained by contacting Tucson Amateur Packet Radio, 8987-309 E. Tanque Verde Road #337, Tucson, AZ 85749-9399.

Telephone: 817-383-0000.

Fax: 817-566-2544.

Internet: tapr@tapr.org.

WWW: <http://www.tapr.org/dcc>.

FO-29 Satgate

Jerry Symth, N8ULU informs us that an FO-29 satgate was demonstrated during a recent Southeast Michigan AMSAT net. The demo included using a newly reconfigured satgate to link several repeaters to FO-29. At 0012UTC on March 19, Mike N8MR, using the N8ULU satgate made contact with four stations including Tom Hughes WB4FWQ, Knoxville, TN; Doug Robertson VA3DGR, Windsor, Ontario; John Taylor VE9PA, New Brunswick; and Dan Seyfert KE0BE, Rochester, MN. While making these contacts, approximately thirty individuals who checked into the net listened to these FO-29 contacts on a 145, 220, and 440 MHz linked repeater for the net and satgate. The consensus during the net was this was one of the most spectacular things heard in this area in some time. What better way to have a AMSAT net than through a satellite! So if

Satellite Summary Sheet - 1997

Analog Satellite Operation

Satellite/Mode	CW QSO's	Phone QSO's
Multiplier	x 3	x 1
Analog Subtotal		

Digital Satellite Operation

Satellite	Upload/Downloads
Multiplier	x 3
Digital Subtotal	

Score Calculation

Analog CW Subtotal (above)	
Analog Phone Subtotal (above)	
Digital Subtotal (above)	
GRAND TOTAL	

Your Field Day Callsign _____

Your Group Name _____

ARRL Field Day Classification _____ Section _____

Power Source: Emergency _____ Commercial _____

Your name and home call _____

Home address _____

Comments _____

Figure 1. 1997 AMSAT Field Day Scoring Form. Send to W5ACM no later than August 1, 1997. Also, don't forget to send in your Field Day photos for publishing in *The AMSAT Journal*.

you hear someone from the Detroit area calling on any of the satellites, ask if they're on the N8ULU satgate. You will hear a lot of us on weekends on AO-27. For additional information on the Southeast Michigan AMSAT Net refer to <http://www.wvnet.com/~jsmyth/index.html>.

JARL "FUJI" Award Available

The Japan Amateur Radio League (JARL) has made available the *Fuji* award for Amateur Radio stations and SWLs who make contact with Fuji OSCAR series satellites. To obtain this award, applicants must make ten different CW or SSB contacts with Amateur Radio stations through the following:

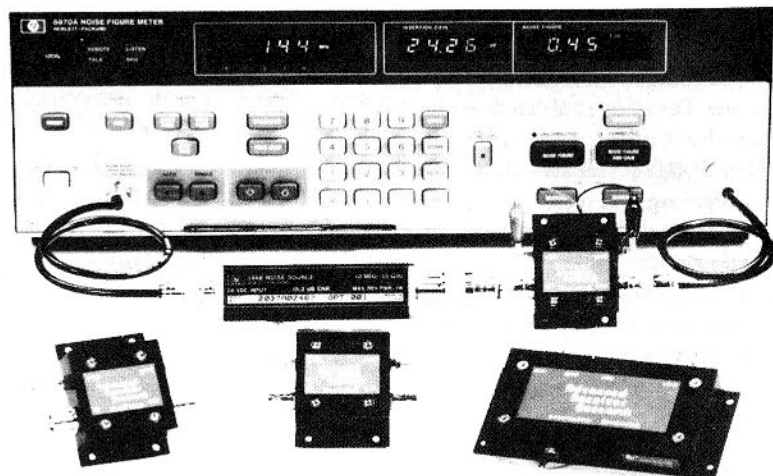
- Amateur Satellite JAS-1 (Fuji, FO-12, 8J1JAS) launched at 20:45 UTC on August 12, 1986.
- Amateur Satellite JAS-1b (Fuji, FO-20, 8J1JBS) launched at 01:33 UTC on February 7, 1990.
- Amateur Satellite JAS-2 (Fuji, FO-29, 8J1JCS) launched at 01:53 UTC on August 17, 1996.

Each claim must be accompanied by a QSL card list furnished with the callsigns of stations worked (heard if SWL), dates, bands and modes of the contacts (receptions if SWL). Each list must be accompanied by a statement from the applicant's national society or from any two Radio Amateurs other than the applicant certifying that the QSL cards of the contacts listed are in the possession of the applicant and that the items of the cards are correctly listed. If such a statement is not available, the applicant must submit all ten QSL cards concerned. A fee of 12 IRCs or US \$16 will be charged. If QSL cards are submitted, sufficient funds for return postage will also be required. Only contacts with amateur stations authorized by their administrations will be acceptable. Contacts with the Far East Military Auxiliary Stations in Japan will not be acceptable. All contacts must be made on land (river/lake) within the same call area or, if no call area exists, within the same country.

All correspondence should be sent to: Japan Amateur Radio League, Attn: Award Desk, 1-14-5 Sugamo, Toshima, Tokyo 170-73, Japan. ■

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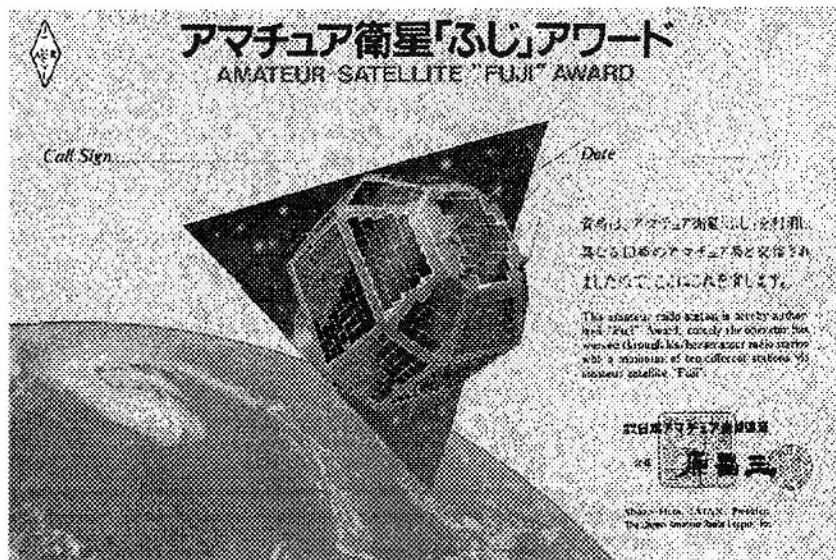


Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	\$29.95
P50VD	50-54	<1.3	15	0	DGFET	\$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	\$79.95
P144VD	144-148	<1.5	15	0	DGFET	\$29.95
P144VDA	144-148	<1.0	15	0	DGFET	\$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	\$79.95
P220VD	220-225	<1.8	15	0	DGFET	\$29.95
P220VDA	220-225	<1.2	15	0	DGFET	\$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	\$79.95
P432VD	420-450	<1.8	15	-20	Bipolar	\$32.95
P432VDA	420-450	<1.1	17	-20	Bipolar	\$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	\$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	\$59.95
SP50VD	50-54	<1.4	15	0	DGFET	\$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	\$109.95
SP144VD	144-148	<1.6	15	0	DGFET	\$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	\$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	\$109.95
SP220VD	220-225	<1.9	15	0	DGFET	\$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	\$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	\$109.95
SP432VD	420-450	<1.9	15	-20	Bipolar	\$62.95
SP432VDA	420-450	<1.2	17	-20	Bipolar	\$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	\$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial, and special preamplifiers available in the 1-1000 MHz range. Please include \$2 shipping in U.S. and Canada. Connecticut residents add 6% sales tax. C.O.D. orders add \$2. Air mail to foreign countries add 10%. Order your ARR RX only or inline preamplifier today and start hearing like never before!

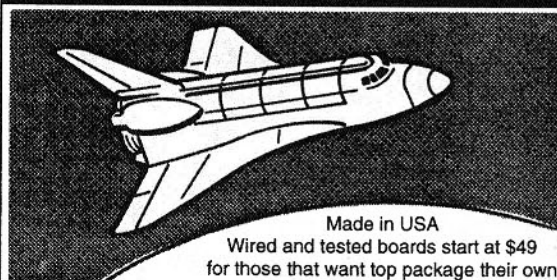
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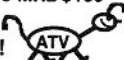
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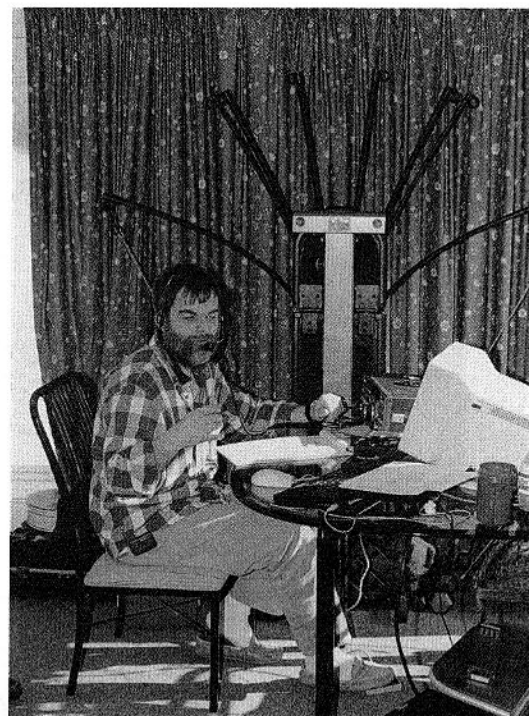
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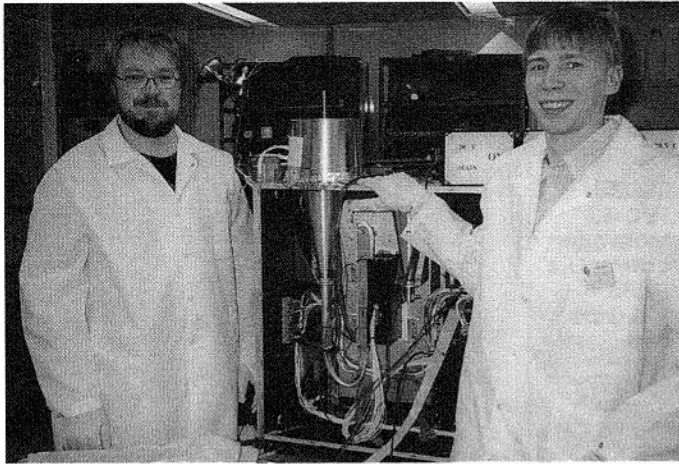
Mike Seguin, N1JEZ operating Special Event Station W1B in Vermont. Note the Phase 3D all-band indoor antenna in background. (Photo by Glenn Ogelby, N1WCK)

Satellite Orbital Elements

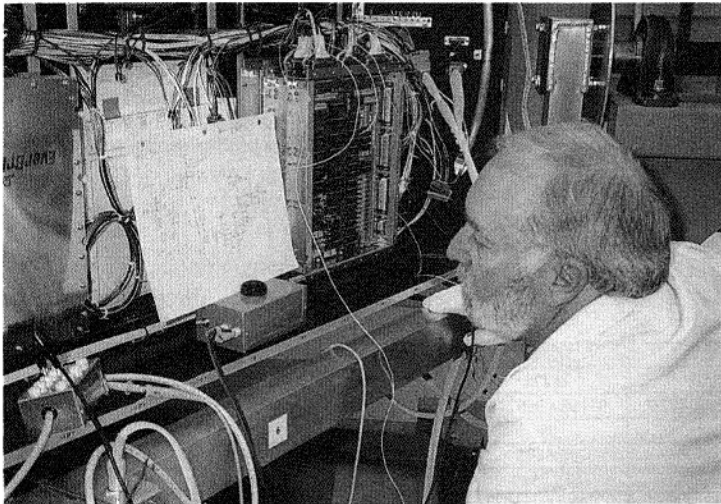
Ray Hoad, WA5QGD

Satellite	AO-10	AO-27	FO-20	FO-29	RS-10/11	RS-12/13	RS-15
Catalog Number	14129	22825	20480	24278	18129	21089	23439
Epoch Time	97098.2294861	97099.7344812	97097.9408339	97098.0919276	97098.0346451	97098.7514168	97099.5130858
Element Set	471	549	964	78	342	969	210
Inclination	25.8122	98.5499	99.0363	98.5495	82.9237	82.9223	64.8097
RA of Node	154.0385	175.4629	72.7686	148.8582	290.5916	330.1497	263.8841
Eccentricity	0.607213	0.0009538	0.054095	0.0351996	0.0013337	0.0029777	0.0151128
Arg of Perigee	106.8498	80.1478	176.4281	7.9626	58.3204	128.0157	145.194
Mean Anomaly	324.7491	280.078	184.093	352.6913	301.925	232.3691	215.8987
Mean Motion	2.05881733	14.27722138	12.83237383	13.52628567	13.72376765	13.74078866	11.27525998
Decay Rate	-0.00000078	0.00000012	0.00000002	-0.00000058	0.00000054	0.00000013	-0.00000039
Epoch Rev	10391	18430	33569	3164	49061	30962	9419
Satellite	RS-16	UO-11	UO-14	AO-16	DO-17	WO-18	LO-19
Catalog Number	24744	14781	20437	20439	20440	20441	20442
Epoch Time	97098.7638027	97098.9229142	97098.1963920	97098.1435147	97100.3052797	97098.1327208	97098.1056176
Element Set	27	963	260	61	59	65	65
Inclination	97.281	97.8282	98.5213	98.5352	98.5423	98.5423	98.5454
RA of Node	5.1265	82.951	181.3735	184.097	187.0341	184.8128	185.4157
Eccentricity	0.0007711	0.0010636	0.0012197	0.0012237	0.0012401	0.0013004	0.0013152
Arg of Perigee	353.6766	222.7849	54.7019	56.2225	49.7465	55.5416	55.5447
Mean Anomaly	6.4377	137.2536	305.5309	304.0122	310.48	304.7003	304.6938
Mean Motion	15.31063184	14.69539342	14.29954715	14.300032	14.30145947	14.30113622	14.3022752
Decay Rate	0.00003691	0.00000144	0.00000015	0.00000022	0.00000006	0.00000003	0.00000021
Epoch Rev	546	70108	37621	37622	37656	37625	37627
Satellite	UO-22	KO-23	KO-25	IO-26	POSAT	MIR	Phase 3D 502 est
Catalog Number	21575	22077	22828	22826	22829	16609	99934
Epoch Time	97098.1320418	97098.5470602	97098.7780508	97098.0964221	97098.0978148	97100.5063674	96.2602552
Element Set	768	653	525	554	561	187	3
Inclination	98.3125	66.0803	98.5443	98.5503	98.5485	51.6522	60.0203
RA of Node	161.1266	291.0478	174.8309	174.0906	174.2527	65.8628	342.7876
Eccentricity	0.0008514	0.0012154	0.0011214	0.0010146	0.0011092	0.0011366	0.6752895
Arg of Perigee	99.194	232.2665	69.1104	86.1014	73.2142	282.4764	180.1221
Mean Anomaly	261.0218	127.7253	291.1276	274.1284	287.0237	77.5614	179.5089
Mean Motion	14.37063558	12.86301759	14.28173167	14.27831029	14.28156527	15.60950247	1.51063968
Decay Rate	0.00000028	-0.00000037	0.00000001	-0.00000021	0	0.00004614	0.0002
Epoch Rev	30042	21879	15230	18408	18412	63648	2

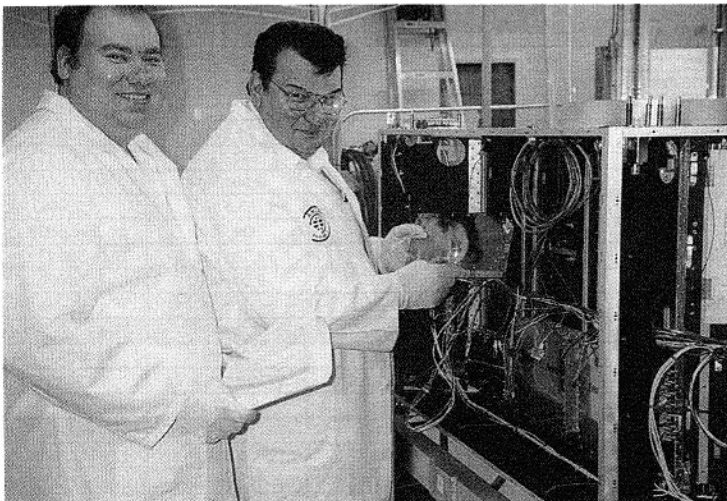
More Phase 3D Photos



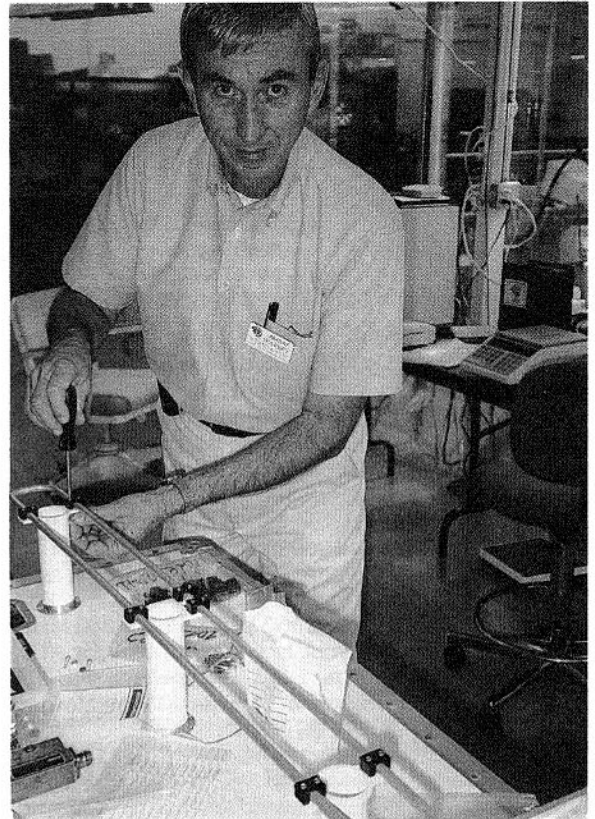
Proud Parents Michael Fletcher, OH2AUE (l) and Harri Leskinen, OH2JMS (r), pause during testing of their Phase 3D 10 GHz transmitter and Traveling Wave Tube (TWT) amplifier during recent integration efforts. The TWT, procured by AMSAT-DL delivered a clean 60 watts output while installed in the spacecraft. (AMSAT-NA photo by Keith Baker, KB1SF)



AMSAT-NA Phase 3D Integration Laboratory Manager Lou McFadin, W5DID, rechecks the wiring and logic of Phase 3D's Internal Housekeeping Unit just prior to activating and testing some of the satellite's recently installed transmitters and receivers. (AMSAT-NA photo by Keith Baker, KB1SF)



AMSAT-DL Digital Integration Manager Peter Guelzow, DB2OS (l) and AMSAT-DL Vice President Werner Haas, DJ5KQ prepare to install the L-Band communication receiver into bay number 5 of the spacecraft. The spacecraft's S, H, and C band receivers are also shown already installed just below and right of Werner's hands. (AMSAT-NA photo by Keith Baker, KB1SF)



AMSAT-NA Assistant VP of Engineering Stan Wood, WA4NFY, puts the finishing touches on one of three V-folded dipole flight antennas for Phase 3D in preparation for its installation on the spacecraft at the Phase 3D Integration Laboratory in Orlando, Florida. (AMSAT-NA photo by Keith Baker, KB1SF)

G0MRF S-Band Converter News

In the April issue of *OSCAR News*, Ron Broadbent, G3AAJ thanked David Bowman, G0MRF designer of a 2.5 GHz signal source and S-Band to 70cm Converter (see article in the Nov/Dec issue of *The AMSAT Journal*.) Why? David has sent AMSAT-UK a check for £312.00 (about US \$600) from profits of the sale of his S-Band Converter kits. Certainly this is a fine effort, especially as David is in business to make a living from similar equipment.

In his letter, David makes reference to small errors in print, and the re-drawing of the circuit both in the RSGB and *The AMSAT Journal*. Be advised of these small errors. Kits purchased from AMSAT-UK have the original and up-dated information included. Efforts are underway to post these changes in a future issue of *The AMSAT Journal* and www.amsat.org for North American users. ■

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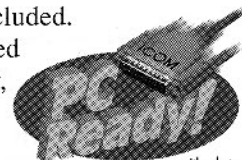
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